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A SERIES OF TEXTBOOKS FOR PERSONS ENGAGED IN THE ENGINEERING PROFESSIONS AND TRADES OR FOR THOSE WHO DESIRE INFORMATION CONCERNING THEM. FULLY ILLUSTRATED AND CONTAINING NUMEROUS PRACTICAL EXAMPLES AND THEIR SOLUTIONS

GAS MAKING
GAS SUPPLY AND DISTRIBUTION
DOMESTIC USES OF GAS
PLUMBING MATERIALS AND TOOLS
SOLDERING AND WIPING
LEAD WORK
PIPE WORK
WASHING AND DRINKING FIXTURES
BATHS AND URINALS

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PREFACE

The International Library of Technology is the outgrowth of a large and increasing demand that has arisen for the Reference Libraries of the International Correspondence Schools on the part of those who are not students of the Schools. As the volumes composing this Library are all printed from the same plates used in printing the Reference Libraries above mentioned, a few words are necessary regarding the scope and purpose of the instruction imparted to the students of—and the class of students taught by—these Schools, in order to afford a clear understanding of their salient and unique features.

The only requirement for admission to any of the courses offered by the International Correspondence Schools, is that the applicant shall be able to read the English language and to write it sufficiently well to make his written answers to the questions asked him intelligible. Each course is complete in itself, and no textbooks are required other than those prepared by the Schools for the particular course selected. The students themselves are from every class, trade, and profession and from every country; they are, almost without exception, busily engaged in some vocation, and can spare but little time for study, and that usually outside of their regular working hours. The information desired is such as can be immediately applied in practice, so that the student may be enabled to exchange his present vocation for a more congenial one, or to rise to a higher level in the one he now pursues. Furthermore, he wishes to obtain a good working knowledge of the subjects treated in the shortest time and in the most direct manner possible.

In meeting these requirements, we have produced a set of books that in many respects, and particularly in the general plan followed, are absolutely unique. In the majority of subjects treated the knowledge of mathematics required is limited to the simplest principles of arithmetic and mensuration, and in no case is any greater knowledge of mathematics needed than the simplest elementary principles of algebra, geometry, and trigonometry, with a thorough, practical acquaintance with the use of the logarithmic table. To effect this result, derivations of rules and formulas are omitted, but thorough and complete instructions are given regarding how, when, and under what circumstances any particular rule, formula, or process should be applied; and whenever possible one or more examples, such as would be likely to arise in actual practice—together with their solutions—are given to illustrate and explain its application.

In preparing these textbooks, it has been our constant endeavor to view the matter from the student's standpoint, and to try and anticipate everything that would cause him trouble. The utmost pains have been taken to avoid and correct any and all ambiguous expressions—both those due to faulty rhetoric and those due to insufficiency of statement or explanation. As the best way to make a statement, explanation, or description clear, is to give a picture or a diagram in connection with it, illustrations have been used almost without limit. The illustrations have in all cases been adapted to the requirements of the text, and projections and sections or outline, partially shaded, or full-shaded perspectives, have been used, according to which will best produce the desired results. Half-tones have been used rather sparingly, except in those cases where the general effect is desired rather than the actual details.

It is obvious that books prepared along the lines mentioned must not only be clear and concise beyond anything heretofore attempted, but they must also possess unequaled value for reference purposes. They not only give the maximum of information in a minimum space, but this information is so ingeniously arranged and correlated, and the indexes are so full and complete, that it can at once be made available to the reader. The numerous examples and explanatory remarks, together with the absence of long demonstrations and abstruse mathematical calculations, are of great assistance in helping one to select the proper formula, method, or process and in teaching him how and when it should be used.

This volume treats of gas making, gas supply and distribution, and appliances for lighting and heating, and is valuable to all who are interested in the use, supply, and distribution of gas for domestic purposes. It also treats of plumbing materials and tools, soldering and wiping, sheet-lead and lead-pipe work, cast-iron, wrought-iron, and brass pipe work, and plumbing fixtures, such as sinks, wash tubs, baths, wash basins, drinking fountains, and urinals. The entire volume is particularly valuable to those engaged in the plumbing and gas-fitting business, such as master plumbers, journeymen, apprentices, helpers, plumbers' bookkeepers, the employes of gas corporations, etc., and for reference purposes to architects, architectural draftsmen, general contractors, building superintendents, building inspectors, plumbing inspectors, board-of-health officials, sanitary inspectors, and others interested in practical plumbing, or modern sanitation.

The method of numbering the pages, cuts, articles, etc. is such that each subject or part, when the subject is divided into two or more parts, is complete in itself; hence, in order to make the index intelligible, it was necessary to give each subject or part a number. This number is placed at the top of each page, on the headline, opposite the page number; and to distinguish it from the page number it is preceded by the printer's section mark (§). Consequently, a reference such as § 16, page 26, will be readily found by looking along the inside edges of the headlines until § 16 is found, and then through § 16 until page 26 is found.

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GAS MAKING

INTRODUCTION

USES OF GAS

ADVANTAGES

1. The use of gas for fuel and illumination has increased enormously within the last decade, and there is a general tendency among manufacturers and domestic users to employ gaseous fuel in preference to coal whenever practicable.

The advantages of gaseous fuel over all forms of solid fuel, in way of convenience and freedom from dirt, are so great that its use is likely to become universal. It is now used for a great variety of mechanical and other manufacturing operations, ranging from the delicate work of tempering hair springs for watches to the gigantic operations of glass melting and steel making. In dwellings, it is used to great advantage for cooking, ironing, drying, heating water, and in recent years has been used successfully for house warming. For direct heating, it is burned in gas stoves and fireplaces, and, for hot-water or hot-air heating, it is used in specially designed boilers and furnaces.

One of the circumstances that tend to increase the general use of gas, is the readiness with which it can, by means of suitable gas engines, be used to generate power. These motors are made in all sizes, from mere toys to engines of 500 horsepower; and, owing to their great convenience and remarkable economy, their use is likely to become general.

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KINDS OF GAS

2. Until recent years only one kind of gas was used for illuminating and heating purposes, and that was obtained by the distillation of bituminous coal. The demand for gas for heating purposes, however, became so great, that new processes were invented, and other varieties of gas have been introduced, so that now all forms of gaseous fuel are called by the general name of **gas.** The kinds of gas now commonly used are as follows: *Coal gas*, *oil gas*, *water gas*, *producer gas*, *natural gas*, *gasoline gas* (or carbureted air), and *acetylene.*

MANUFACTURE OF GAS

COAL GAS

PROPERTIES

3. Introduction.—Coal gas is produced by the destructive distillation of bituminous coal in ovens, or retorts. These are as nearly as possible air-tight and are heated externally by a furnace. A very simple experiment, that may be used to illustrate the production of coal gas in a crude way, is as follows: Take an ordinary clay pipe and, nearly filling the bowl with soft coal such as blacksmiths use, close the mouth of the bowl with damp clay. Place the pipe in a fireplace or stove in such a way that while the bowl is in the fire the stem will be outside. In a short time coal gas will begin to issue from the small hole in the stem, and on being lighted this gas will burn with a bright flame in a manner similar to ordinary illuminating gas.

4. Composition.—Coal gas is not a simple gas, but is a mixture of a number of gases the amounts of which, present in a given volume of coal gas, vary somewhat according to the kind of coal used and the temperature at which it is carbonized.

The following may be considered to be about the average results found by a volumetric analysis:

Hydrocarbon vapors	.6
Carbon dioxide	3.4
Heavy hydrocarbons	4.4
Oxygen	.3
Carbon monoxide	10.1
Hydrogen	45.9
Marsh gas	30.6
Nitrogen	4.7
	100.0

The above is an analysis of purified gas from which the carbon dioxide has not been removed.

5. **Impurities.**—In the unpurified state, coal gas also contains ammonia, sulphureted hydrogen, and a small percentage of other compounds, mainly carbon bisulphide. Of these impurities, the two former must always be removed, but the amount of carbon bisulphide present is so small that in most American works no attempt is made to remove that which escapes with the gas after it has passed through the washer. When the gas is driven out of the coal by heat, it contains a certain proportion of hydrocarbons that are volatile only at a high heat; these begin to condense as soon as the gas begins to cool, forming **tar.** The non-volatile part of the coal, which remains when all the gas has been driven off, is called **coke.** In addition to this, some of the hydrocarbons attach themselves to the hot walls of the retorts, forming **retort carbon,** which must be removed at intervals of from 2 weeks to 2 or 3 months, according to the conditions under which the retorts are operated. The length of time required to drive the gas entirely from the coal varies according to the heat to which it is subjected, less time being required as the temperature of the retort is raised.

It is now almost the universal custom to keep the retorts at such a temperature as is sufficient to drive off the gas in about 4 hours. Under these conditions a long ton, or 2,240 pounds, of good gas coal should produce about 10,000 cubic feet of about 17-candlepower gas, about 1,400 pounds of coke, 12 gallons of tar, and 4 pounds of ammonia. With coal of inferior quality, however, these figures might be very much different.

The term **candlepower of a gas** defines its light-giving quality. It is measured while the gas is burning in an open burner at the rate of 5 cubic feet per hour, and comparing the light emitted with that of a **standard candle.** This candle is one that will burn 120 grains of spermaceti per hour.

6. Enriching Gas.—In many works, the gas is enriched to over 20 candlepower either by mixing with water gas, or by the use of oil, or cannel coal. This coal yields gas of high illuminating value, but the coke from it is of poor quality.

7. Gas Coal.—Gas coal, to get the best results, should be broken into lumps from 2 to 3 inches square and should be as free as possible from slack. The following is an analysis, by weight, of fairly good gas coal:

Volatile matter	36.00
Fixed carbon	57.96
Water	1.51
Sulphur	.93
Ash	3.60
	100.00

8. Specific Gravity and Odor of Coal Gas.—Ordinary coal gas has a specific gravity of about .45, air being taken as unity. It yields about 650 British thermal units per cubic foot.

The well-known pungent odor of coal gas is due mainly to the **olefiant gas,** composed of what is known as the heavy hydrocarbons, which are present.

BY PRODUCTS

9. The **by products** of coal-gas manufacture are *coke*, *tar*, and *ammonia*.

10. **Gas coke** is not hard enough for blast-furnace work, but it makes an excellent domestic fuel, as it burns freely with a light draft, gives no smoke, and is clean to handle. Most gas companies find a ready market for all the coke that is not used about the works. Coke is frequently sold by the bushel instead of by weight. It weighs from 23 to 32 pounds per cubic foot, and from 35 to 42 pounds per heaped bushel, averaging about 38 pounds.

11. In the early history of gas manufacture there was little demand for **tar,** and it was frequently allowed to run to waste or was burned, but modern chemistry has developed the fact that coal tar is a very complex substance, containing more than 600 different products, among which are many different kinds of coloring matters and chemicals of commercial value. Tar is also of considerable value as a fuel and is sometimes used as such in the gasworks. It is usually sold by the gallon.

12. **Ammonia** is produced during the carbonization of coal by the union of hydrogen and nitrogen. It is readily absorbed by water, which will take up about 700 times its own volume of ammonia gas, at a temperature of 60° F. As the temperature of water is raised, it rapidly loses its power of absorbing ammonia, and at 180° no ammonia can be absorbed. Ammonia is always removed from gas by allowing the gas to come in contact with water, the supply of which is usually so regulated that a weak ammoniacal liquor of about 2° specific gravity, as shown by a Twaddle hydrometer, is produced. This is usually distilled at the works, and either ammonium sulphate or crude ammoniacal liquor, which is from 15 to 20 per cent. ammonia, by weight, is produced. It is then sold on the basis of the number of pounds of ammonia in the material.

A COAL-GAS PLANT

13. Retorts.—In Fig. 1 is shown the general appearance of a bench of retorts. The retorts *a*, *a* are heated by means of a fire on the grate *l*. From *a*, the gas passes up through the stand pipes *b*, *b* and through the hydraulic main *e*, where the greater part of the tar and water vapor is removed. Each pipe *b* curves downwards on entering *e*, and has its mouth below the surface of the tar and ammonia contained in *e*. This forms an effectual seal, preventing the gas from flowing back to the retorts when they are opened for charging. The surplus tar and water flows off through the pipe *h* to the tar well. From the hydraulic main, the gas passes through *c*, *c* to an exhauster, or pump, and thence to the condenser.

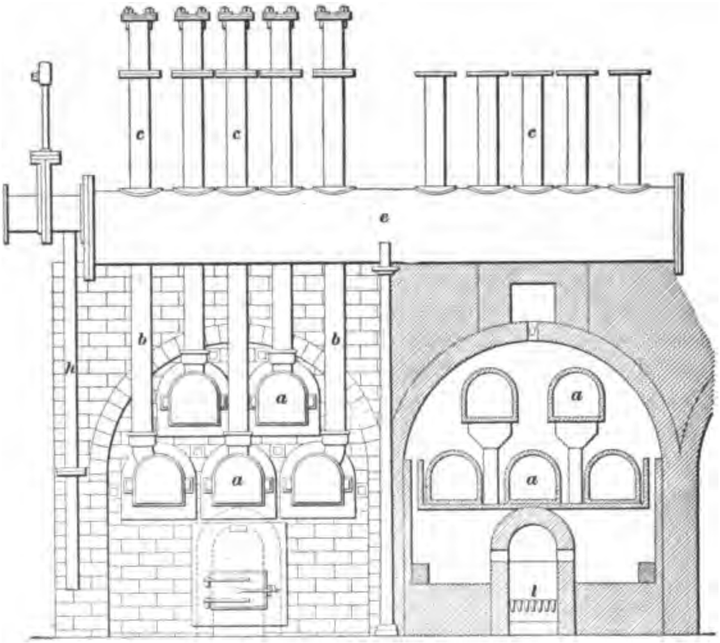


FIG. 1

14. General Arrangement.—A general idea of an entire plant may be obtained from Fig. 2, wherein the exhauster and station meter are omitted. The station meter is a large device used for measuring the gas, and is placed between the purifier and the gas holder. The exhauster is placed between the condenser and the scrubber to avoid back pressure in the retorts. Referring to Fig. 2, the gas passes from the hydraulic main *e* through *c*, and down *d* to the condenser *f*, where the gas is compelled to pass through the curved pipes. These pipes are sometimes cooled by the atmosphere, in which case the number of pipes must be very large. In others, the pipes are surrounded by water, and the number of pipes can be made very much less than when cooled by air. After passing through *f*, and leaving the remainder of the tar water behind in the base of the condenser, from whence the overflow passes out through the bent pipe *i*, the gas goes to the scrubber *g*. There it passes over large wet surfaces, such as coke or small wood brush. Should any of the tar remain, after passing through the condenser, it is deposited in the scrubber. Only a small portion of the ammonia is carried past.

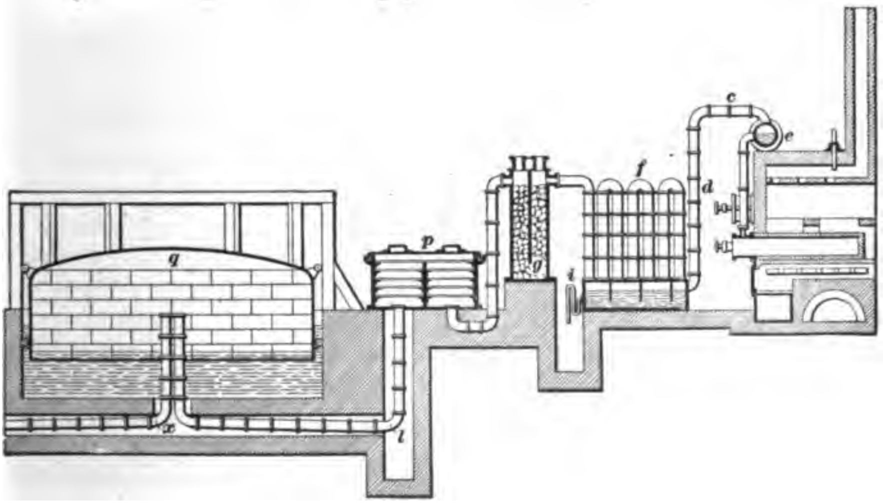


FIG. 2

The gas still contains some sulphur compounds and carbon dioxide. To free it from these substances, the gas next goes to the purifier *p*, where it passes through trays of dry or slightly dampened lime. This removes most of the impurities, and the gas, now ready for use, flows through *l* to the gas holder *q*, where it is stored. From *q* it passes through *x* to the station meter and pressure governor, and thence to the gas mains.

WATER GAS

PROPERTIES

15. Composition.—**Water gas** is a mixture of hydrogen and carbon monoxide. It is made commercially by the contact of steam with incandescent carbon in the form of anthracite coal or coke. The steam is decomposed, the hydrogen being separated from the oxygen. The oxygen takes up carbon from the coal or coke and forms carbon monoxide, along with a small amount of carbon dioxide. The resultant gases from the contact of steam with incandescent carbon are then mainly hydrogen and carbon monoxide, chemically separate but mechanically mixed together. This is what is called **blue, or uncarbureted,** water gas. It burns with a non-luminous flame and is consequently useless for lighting purposes except in incandescent lamps of the Welsbach type. In actual practice, this water gas is always enriched with oil gas, which furnishes the hydrocarbons necessary to make a luminous flame. The oil gas was made separately in many of the older forms of apparatus, but it is now commonly produced in the same machine in which the water gas is made.

16. Impurity.—The only impurity found in water gas, which must be removed, is sulphureted hydrogen, which is formed from the sulphur always present in greater or less amount in the coal or coke, and sometimes in the oil. The sulphureted hydrogen is removed by purification with lime or iron oxide, in the same way that the purification of coal gas is accomplished.

Carbon dioxide, which is formed by either imperfect contact of the steam with the incandescent carbon, or because the temperature of the carbon is too low, is not a dangerous impurity, but is merely an inert gas, incapable of combustion. However, it absorbs heat when the gas is burned, and consequently reduces the heating and lighting power. It can be removed by purification with lime, but purification is not necessary if the generating apparatus is handled properly, as the quantity made will be very small. No ammonia is produced.

17. Analysis.—The following is a volumetric analysis of a sample of purified water gas:

Hydrocarbon vapors	1.2
Carbon dioxide	3.0
Heavy hydrocarbons	12.6
Oxygen	.4
Carbon monoxide	28.0
Hydrogen	31.4
Methane	20.2
Nitrogen	3.2
	100.0

18. Coal and Oil Required.—Water gas requires from 30 to 40 pounds of coal or coke per 1,000 cubic feet of gas made, and from 4 to 5 gallons of oil, depending on the candlepower required. Usually between 5 and 6 candlepower is obtained from each gallon of oil used. There are about 300 heat units yielded per cubic foot of uncarbureted water gas, and about 625 heat units are yielded by 24 candlepower carbureted water gas. The specific gravity of 24 candlepower water gas is about .625, air being taken as unity.

Pure uncarbureted gas has no perceptible odor, but the carbureted gas has an odor fully as strong as coal gas. This is mainly due to the hydrocarbons from the oil that is used for enriching.

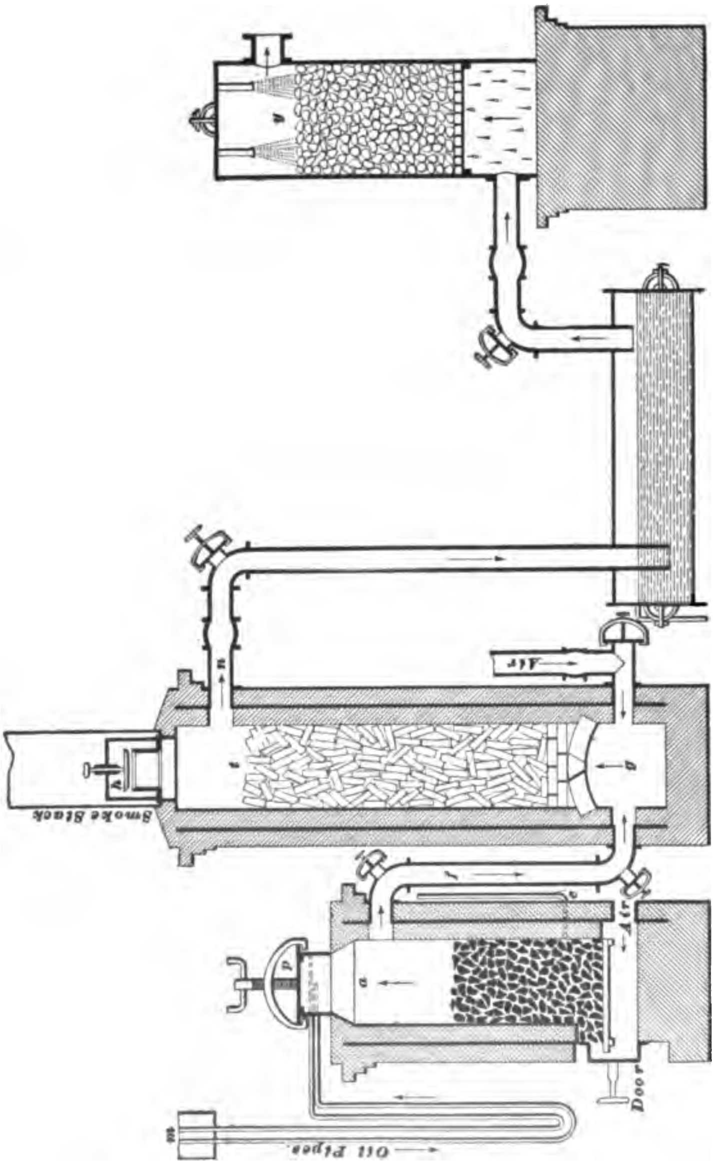


FIG. 8

WATER-GAS MACHINES

19. Almost all the **water-gas machines** now in use are modifications of the **Lowe type.** The Lowe type of machines consist of a generator, where the blue water gas is produced, and a superheater, or a carbureter and a superheater, where the oil is vaporized and mixed with the blue water gas. The generator is a circular steel sheet, the height of which is about one and a half times the diameter. It is lined with a double lining of firebrick blocks and is provided with grate bars at the lower end and with air-tight doors at the top, where the coal is charged in, and at the bottom, where the clinkers are taken out. There are also connections for the escape of the gas and for the proper supply of steam and air. The capacity of any generator depends largely on the grate area and may be figured at a minimum of 20,000 cubic feet of gas per square foot of grate surface per 24 hours.

20. An example of a water-gas plant is given in Fig. 3. The generator *a* is first filled, to the height shown in the figure, with clean anthracite, egg size. The coal is fed through *p*, from the second floor, where the coal is stored. The coal in the generator is ignited, and is raised to a very high temperature by means of an air blast. The gases passing through the pipe *f* in the direction of the arrows again meet with an air blast at *g*, which blows them in a hot flame through the superheater *t*, and out through the valve *h* to the smokestack. The body of the superheater is filled with loose firebrick, which takes up the heat from the passing gases.

On the bricks becoming sufficiently heated, the air blast is shut off, the valve *h* is closed, and steam at a very high temperature enters through the pipe *e*. Coming in contact with the white-hot coal, the oxygen and hydrogen separate, forming water gas with the carbon of the coal. This gas passes through the superheater, where any steam remaining is further broken up, and flowing out through *n* passes through the washer to the scrubber *y*, and thence to the condensing apparatus.

The water gas, as it now is, burns with a pale-blue flame, giving little or no light. On this account it is necessary, in order to make the gas a good light giver, to add some hydrocarbon. For this purpose oil is allowed to flow in a fine stream into the generator from the reservoir *m*, during the passage of the steam. These hydrocarbons make the gas flame white, and water gas, properly treated in this way, gives a much brighter flame than coal gas. The hydrocarbons are often added after the gas is purified; they are not needed, however, when the gas is to be used for heating purposes or for gas engines.

ARCHER GAS

21. Archer gas is water gas made from crude petroleum by a continuous process; it derives its name from the inventor of the apparatus. The oil is pumped in a small stream into a red-hot retort, where it is quickly reduced to vapor by the heat. The oil vapor is then mixed with a current of superheated steam, and the mixture is driven through a long coil of very hot pipe. The oxygen of the steam unites with the carbon of the oil, forming carbon monoxide, and the hydrogen is set free. The resulting gas is permanent, and is of high value for heating purposes. It is produced at a pressure of 8 to 10 pounds per square inch.

OIL GAS

THE PROCESS

22. Oil gas is made, in much the same manner as coal gas, by the process known as destructive distillation. This process consists in heating the oil to a very high temperature and causing the heavy hydrocarbons it contains to break up into the lighter or gaseous forms.

In the månufacture of this gas, not only is petroleum utilized, but also there are many animal and vegetable fats and oils used as well; among these are to be found the waste fats that occur in the manufacture of woolens, and ordinary rosin.

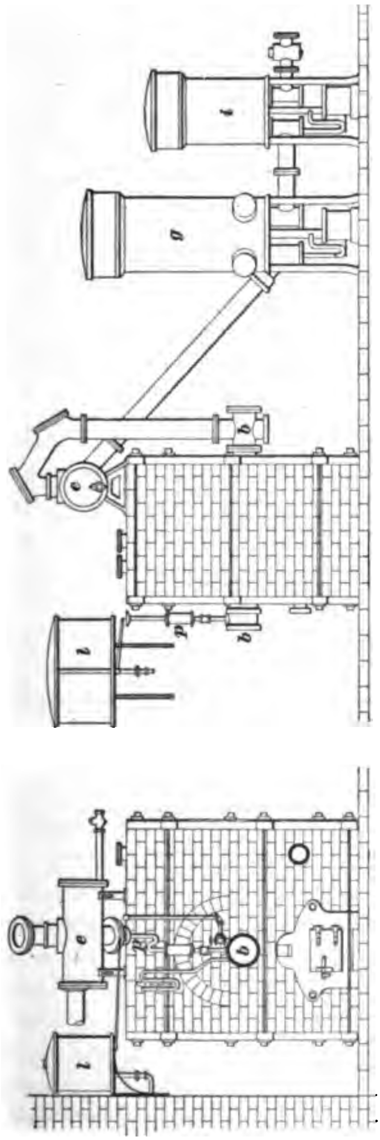


FIG. 4

OIL-GAS PLANT

23. An example of an **oil-gas plant** is given in the accompanying illustration (Fig. 4). From the oil-supply tank *l*, oil is allowed to flow into the pipe *p*, which has the form ∽ in order that some of the oil will remain in the curve and prevent the gas from escaping through the pipe *p*. The retort *b* is kept at a bright-red heat, in order that, as soon as the oil strikes it, it may become gasified; it then passes out through the hydraulic main *e* to the combined scrubber and condenser *g*, and the purifier *i*. Oil gas is used extensively in lighting railroad trains, under the Pintsch system.

PRODUCER GAS

PROPERTIES

24. Producer gas, properly so called, is made without the aid of water in the generator. It is, in fact, nothing more than the products of incomplete combustion of the fuel used. The average quality of producer gas contains 10 to 15 per cent. of hydrogen, and 20 to 30 per cent. of carbon monoxide. These constitute the combustible part of the gas, nitrogen forming about 40 to 60 per cent. of the total volume. This gas burns with a dull reddish flame, and its value for heating purposes is about one-fourth that of an equal volume of good coal gas.

Semi-water gas is a combination of water and producer gas, which, while containing less nitrogen and a larger percentage of carbon monoxide and hydrogen than producer gas, is made by a continuous process.

GENERATION

25. Suppose the generator *a*, Fig. 3, to be connected directly to the washer. The air blast being on, the gas is allowed to pass directly through *f* to the washer. Then, if the air supply is properly regulated, the carbon of the fuel burns to carbon monoxide, a highly inflammable gas; the nitrogen of the air is carried with the gas, and we have, as a result, a mixture of carbon monoxide, carbon dioxide, and nitrogen, together with small quantities of marsh gas and hydrogen that were originally combined with the carbon in the coal. Nitrogen forming, as it does, four-fifths of the atmosphere, must necessarily be present in a large quantity. This gas will neither burn nor assist in burning, but is a nuisance, particularly when the gas is used in the gas engine, as it takes up room and carries off heat. More than half, usually about six-tenths, of the volume of producer gas consists of nitrogen. As this gas cannot be gotten rid of by any inexpensive process, the value of producer gas for gas-engine use is not very great. It can be used with profit, however, where the gas would otherwise be wasted, as when made in the manufacture of pig iron, or where the gas is made from very cheap coal refuse, as culm. The manufacture of producer gas being a continuous process, has led to the invention of the modern, so-called producer-gas processes, in which water plays an important part.

ACETYLENE

PROPERTIES

26. Acetylene is a pure hydrocarbon gas; it is represented by the chemical formula C_2H_2.

Acetylene contains a higher percentage of carbon than any other hydrocarbon, the composition by weight being 92.3 per cent. carbon and 7.7 per cent. hydrogen. The gas is colorless, and the commercial article has a strong odor suggestive of garlic. This odor is mainly due to the presence of small quantities of various impurities; where these are not present there is only a slight, and by no means disagreeable, ethereal smell. Acetylene is very readily soluble in water. At ordinary temperatures, 12 cubic feet of water will absorb about 13 cubic feet of acetylene. The specific gravity is .91, air being taken as unity. In burning 1 cubic foot of acetylene, 1,385 heat units are developed. Acetylene burns with almost perfect combustion and no smell is noticeable from the burners. Where an odor of acetylene is discernible, it is an evidence that there is a leak. Acetylene gives a clear white light very similar to sunlight, and all substances show their true colors when illuminated by it.

The candlepower, under the most favorable conditions, is about 240 for a consumption of 5 cubic feet per hour, but it must be noted that it is impossible to get economical results with a flame giving more than 50 candlepower.

Acetylene is usually burned through **half-foot burners,** that is, burners that burn ½ cubic foot of gas per hour, each burner yielding in ordinary practice about 20 candlepower. Where more light is desired in one place several such burners are grouped together.

PRODUCTION

27. Materials.—Acetylene is produced commercially by adding water to a substance known as **calcium carbide.** This is a stone-like material, usually dark-brown or black in color. It cannot be burned and will keep indefinitely if kept sealed from the air. If left exposed, the moisture in the atmosphere gradually slakes it and it eventually turns to slaked lime. It always gives off an acetylene odor due to the fact that the moisture in the air is constantly decomposing it and producing small quantities of acetylene.

Calcium carbide is produced by fusing together carbon, in the form of ground coke and lime, in the intense heat of an electric furnace.

When water is added to calcium carbide it is decomposed according to the following formula:

$$\underset{\text{Carbide}}{CaC_2} + \underset{\text{Water}}{2H_2O} = \underset{\text{Slaked Lime}}{Ca(OH)_2} + \underset{\text{Acetylene}}{C_2H_2}$$

One pound of absolutely pure calcium carbide will produce about 5.5 cubic feet of acetylene, but carbide as usually sold is not pure, and the yield of acetylene will be 5 cubic feet, or less, per pound of carbide.

28. Impurities.—The impurities found in calcium carbide, and consequently in acetylene, are phosphorus, sulphur, ammonia, and traces of hydrogen and silicon hydride. Any unfused carbon, and the ash from the coke, that may be present in the calcium carbide, will be found in the residue of slaked lime after the gas has been driven off.

The phosphorus and sulphur, in the form of phosphureted hydrogen and sulphureted hydrogen, are the only impurities that might prove objectionable, but where good carbide is used the quantities of these are so small that they may be neglected.

29. Purification.—The ammonia and sulphureted hydrogen may be largely removed by the washing that the gas gets in a carbide-feed generator as it bubbles up through the water, or in the case of a water-feed generator, by making the gas bubble through a washer after it is generated. Any considerable amount of phosphureted hydrogen in acetylene will cause burner stoppage and the production of a kind of white haze, which is also produced when acetylene is burned where there is not good ventilation, as in store windows. Where it is necessary to remove the phosphureted hydrogen, it can be done by passing the gas through a chemical scrubber containing some oxidizing agent, such as chromic acid, or through chloride of lime. The latter is perhaps the most efficient purifying agent, but it is difficult to use because it has a tendency to lump together when moist and prevent the easy passage of gas. A substance known as **puratylene** has, however, been invented, which does the work excellently. It is a mixture of chloride of lime with other lime salts, and is produced in a porous lumpy state. It causes but little resistance to the passage of gas, and removes not only all the phosphureted hydrogen but also the water vapor, so that the condensation of water in the pipes is avoided. The vessel that contains it is usually placed at the outlet of the gasometer or storage tank, so that the gas after passing through it does not come in contact with any more water but goes directly into the pipes for use. The purifying vessel is usually a small cylindrical tank that is partly filled with the purifying material. The gas is usually passed in at the top of this vessel and out at the bottom.

30. Heat Generated.—In the production of acetylene, a large amount of heat is generated. This heat may be localized so as to be harmful to the acetylene produced, or it may be diffused so as to do no harm, according to the way the water and acetylene are brought together.

Thus, if water is allowed to drip slowly on a mass of carbide, local overheating will occur and the acetylene may be partly broken up into other hydrocarbon compounds of an oily nature; the candlepower will be much reduced thereby and there will be a tendency for the burners to clog and carbonize.

31. Lime Dust.—Carbide, when heated, has a tendency to give off lime dust, which will choke the burners and may even fill the pipes up completely with a deposit of lime. This trouble may be partly overcome by the use of filters of cotton or thin cloth, or by making the acetylene bubble through a washer. Where the carbide is dropped in small lumps into a considerable volume of water, the water absorbs the heat and the gas bubbles out of the water, cool and free from dust.

32. By Product.—The sludge of lime waste that is left after all the acetylene has been evolved should be of a whitish color; if yellow or brown, it is a sure indication that the heat has been too high. This residue is harmless and will not burn. It packs well and makes good walks or drives, and as it consists mostly of the hydrate and carbonate of lime, it is valuable as a fertilizer.

33. High Pressure.—Acetylene is an **endothermic compound.** This means that heat is absorbed when it is developed and is given off when it is decomposed. If acetylene is compressed, so that the particles of gas are forced together more, by a pressure of 150 pounds to the square inch, or more, it may be decomposed when subjected to high heats and may become violently explosive. The use or possession of liquid acetylene or of acetylene at high pressure is dangerous and should be avoided, but acetylene at ordinary temperatures cannot be exploded, unless it is mixed with air and ignited. If subjected to high heats at ordinary pressures, without the presence of air, it will merely decompose into other hydrocarbon forms, such as benzine, methane, etc.

34. Explosiveness. — Acetylene, in common with all other combustible gases, is explosive when mixed with air in certain proportions. One part of acetylene mixed with 12.5 parts of air will produce perfect combustion and most violent explosion, but an admixture of from .03 to .82 parts of air will also explode with violence. Moreover, the igniting temperature of acetylene is comparatively low. While ordinary coal gas ignites at about 1,100° F., the ignition point of acetylene is about 900° F., and it may therefore be lighted by a cigar or cigarette. It will readily be seen from the foregoing statement that acetylene must be handled with care, but as a mixture of 1 part of acetylene in 10,000 parts of air may be readily detected by the smell, leaks may be located and stopped long before there is danger of an explosion.

It is dangerous, however, to look for leaks with a match or candle, and all tests should be made with a little soap and water. The soap suds should be brushed on wherever a leak is suspected; the formation of soap bubbles will indicate its location.

35. With properly installed piping and a properly constructed and placed generator, there is absolutely no danger in the production of acetylene in the cellars or other suitable parts of residences, provided the apparatus is handled by a person who has been properly instructed, and provided good judgment and common sense are used.

This is made evident by the fact that the Fire Underwriters make no objection to the installation of any one of the numerous generators that have been tested and approved by their experts, and are installed in accordance with the requirements of local laws or ordinances.

GENERATORS

36. Types.—There are five general types of generators in use; viz., the *spray type*, the *overflow type*, the *recession type*, the *dip type*, and the *drop*, or *plunge*, *type*.

37. The **spray generator** is shown in Fig. 5. It consists of a drum, or shell, *a*, either cylindrical or square, into which a pan *b* of carbide is introduced through a removable head *c*. Water from a spray tube *d* is allowed to drip on this carbide, as shown, the supply being usually cut off automatically by the increase in pressure of the gas in the generator, or by the raising of the bell of a small gas holder when gas is produced more rapidly than it is required.

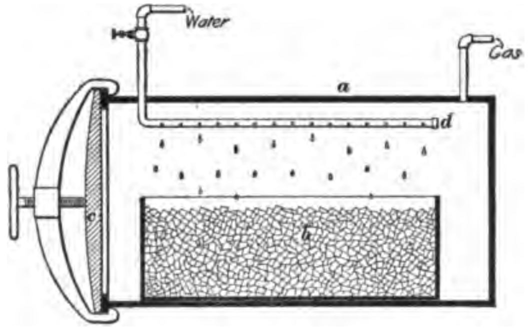


FIG. 5

Spray generators are likely to overheat the gas, causing a loss of candlepower, and the choking of the burners.

Steam is frequently generated when the water strikes the carbide and lime dust is thrown off, which will clog the pipes and burners. This type of generator is divided into two subdivisions, the **dry** and **wet.** In the first form only enough water is added to produce the gas, the residue being removed in a dry state. These machines are wasteful because some of the carbide is frequently removed unused, and the unused carbide is sure to give the residue a very strong odor. In the wet machines enough water is run in to flood the carbide before it is removed.

38. On account of the overheating and the lime-dust trouble, the spray type of generator is suitable only for special conditions, such as occur in bicycle lamps, where the spray or drip system is the only practical way to apply the water to the carbide.

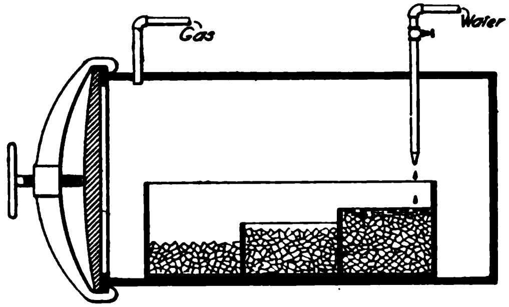


FIG. 6

39. In the **overflow generator,** shown in Fig. 6, the carbide pan is divided into a number of small compartments so arranged that when water is turned into the first compartment it floods the carbide in that before it overflows and begins the generation of gas in the second. The compartments are thus successively filled and overflowed, until the carbide has all been flooded. The water feed may be automatically regulated by the gas pressure or by a mechanism on the gas holder.

Generators of this type are open to the same objections as those of the spray type, though perhaps to a smaller degree. Some of them give very fair results in practical use.

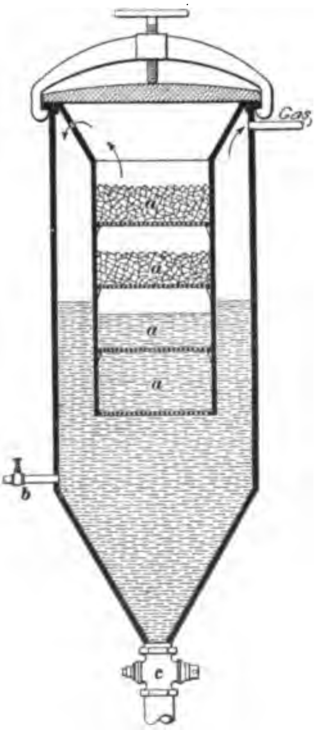


FIG. 7

40. In the **recession generator,** shown in Fig. 7, the carbide is held suspended in baskets or perforated pans *a*, *a*, and water is allowed to rise in the generator until it reaches the carbide, when the production of acetylene begins. Should gas be produced faster than it is needed, the pressure forces the water down, away from the carbide, and back through the water-supply pipe *b*, when generation ceases. The water and residue are drained off through a drain pipe provided with a cock *c*, or valve, at the bottom of the generator. If the water comes up to the carbide and produces vigorous generation and then quickly recedes, the carbide is apt to become so hot as to be incandescent, and great damage to the quality of gas results. Different makes of generators vary in their tendency to cause this trouble.

41. In the **dip generator,** shown in Fig. 8, the carbide is placed in baskets or perforated pans *a*, *a*, which are suspended from the inside of the bell *b* of a small gas holder or gasometer. As gas is taken from the holder, it gradually lowers until the carbide comes in contact with the water in the tank. Acetylene is then generated, and if the rate of generation exceeds the demand, the gas accumulates under the bell and raises it until the carbide does not touch the water, when the generation of gas soon stops. The carbide in this generator is very apt to become overheated, just as in the recession apparatus.

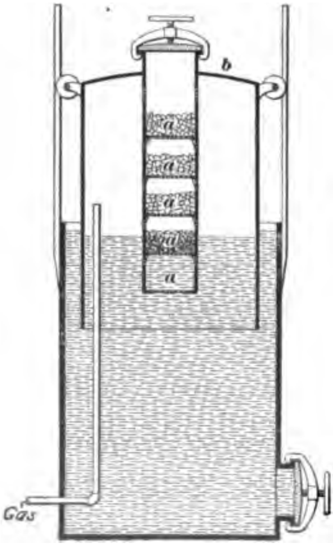


FIG. 8

42. In the **drop generator,** shown in Fig. 9, the carbide is allowed to fall, a small piece at a time, from a carbide chamber, as at *a*, into a large volume of water. Since the small piece of carbide is dropped into a large quantity of water, the water absorbs the heat as fast as it is generated, so that the gas produced is cool, that is, below 212° F., and is consequently of excellent quality. As the gas bubbles up through the water it is thoroughly washed and a large proportion of the impurities are removed. The residue, or lime sludge, drops to the bottom, as at *b*, and is removed from time to time. It has been claimed that a considerable loss of acetylene results in this form of apparatus on account of the fact that 1 cubic foot of water will absorb a little over 1 cubic foot of acetylene. This is true if the gas has access to pure water, but as the water in the generator is constantly taking up lime, the gas absorbed when water is freshly added is largely driven out again and the acetylene loss is very slight.

In theory, the amount of water required to produce all the acetylene from 1 pound of carbide is .56 pound, or a little over half a pint, but 1 gallon to the pound is nearer the usual practice.

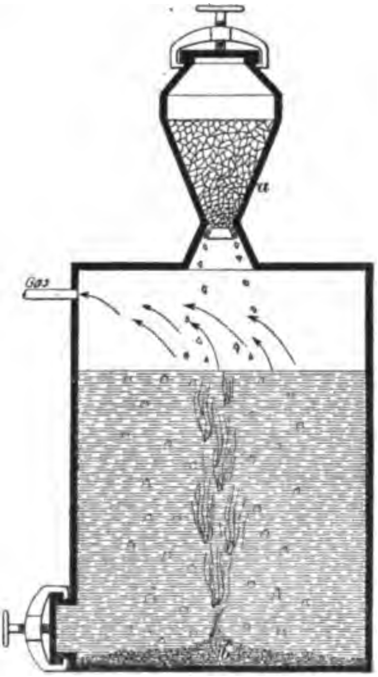


FIG. 9

43. The granulated carbide is fed into the drop type generator either by hand or automatically. The former method is suitable for large establishments and public lighting plants, where considerable holder capacity is at hand and where an attendant can give regular attention to the feeding.

In the early history of acetylene lighting, great difficulty was encountered in constructing an apparatus that would successfully feed granulated carbide automatically, but the problem has now been solved by many makers of generators.

44. Gas Holder or Storage Tank.—All generators should be provided with a storage tank of the gas-holder type to take up and store the gas that generates after the flow from the machine has been cut off. The storage tank prevents an undue pressure in the generator due to this after-generation.

45. The gas holder shown in Fig. 10 is considered to be the best storage tank, because it not only serves to store the gas, but also acts as a pressure regulator and maintains a constant pressure in the piping system. Gas enters the gas holder from the generator through *a* and flows up an inner tube *b* to the space under the floating bell *c*; it then flows down through another inner tube *d* to the gas-service pipes. The bell rises and falls in the water, thus changing its gas-holding space to suit changes in the volume of gas delivered by the generator without materially changing the pressure in the gas pipes. The water at *e* serves as a seal for the mouth of *a*, while the base of *d* extends into *e* to act as an overflow for the lower chamber. The rod *f* is a guide for the bell.

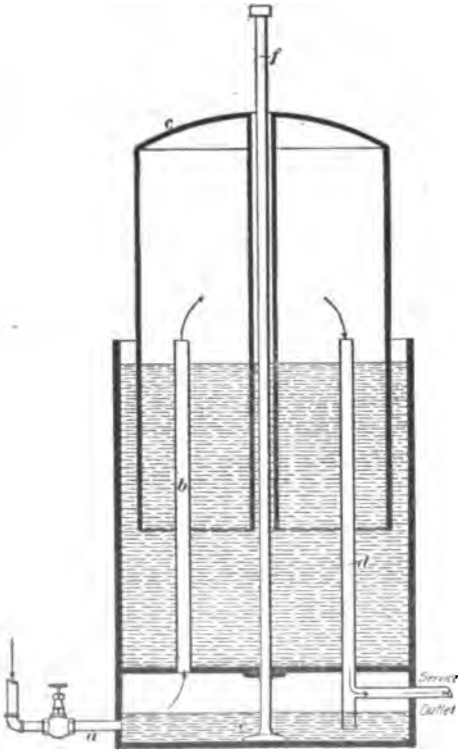


FIG. 10

46. Another form of storage apparatus consists of two tanks that are connected together at the bottom and partly filled with water, the top of one being open to the atmosphere. When gas is admitted above the water in the closed tank, the pressure of the gas forces down the water in that tank and correspondingly up in the other tank. This apparatus has the disadvantage of a variable pressure, the pressure increasing as gas is added. Consequently, some form of a reducing valve must be placed on the outlet gas pipe in order to insure a steady pressure at the burners, and hence steadiness of light.

47. Safety Blow-Off.—All generators should be provided with a safety valve, or seal, that will open at a pressure equivalent to 6 inches of water, and is connected with a pipe leading to the outside of the building. The safety valve, or seal, is intended to prevent an excess of pressure in the generator.

As no mechanical blow-off valve will work properly at the low pressures usually employed in gas lighting, the best blow-off is formed by a piece of pipe dipping 6 inches into a water seal. Such a seal will reseal itself when the pressure goes down.

Fig. 11 shows the operation of such a seal. The gas pipe *a* connects the trap to the gas holder, or generator, but no valve or shut-off cocks must be placed between this trap and the generator. The gas passes up through *b* to the gas fixtures. When the pressure in *a* becomes great enough, gas blows down through *c*, rises through the water in the trap, and blows to the atmosphere through *d*. The pipe *e* is an overflow to prevent the trap from filling with water and thus increase the resistance to a blow-off.

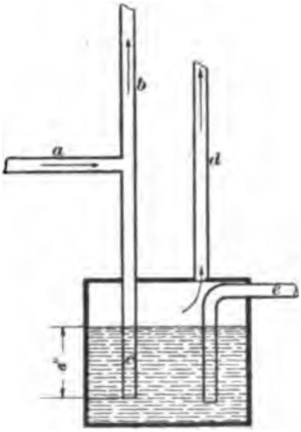


FIG. 11

Care should be exercised that the trap always contains sufficient water. The outlet pipe *d* should never project down far enough to enter the water, since water will then be forced up into *d*, in consequence of which the pressure may run up high enough to force the water out of the trap. The pipe *e* should have a tee with a short vertical piece of pipe at its highest point outside the trap in order to prevent any siphonic action.

48. Number of Lights.—Generators should never be connected with a greater number of lights than they are designed to carry, and they should preferably be operated on a smaller number of lights than they are rated for by manufacturers, in order to insure safety.

49. Overheating in Generators.— Overheating is caused by overloading, and results in too rapid generation; this causes a breaking up of the acetylene into other hydrocarbons, such as acithracene, benzine, stybolene, etc.

50. Requirements of a Good Generator.—The following are the points on which judgment was passed in awarding medals to the acetylene generators at the Pan-American Exposition at Buffalo, New York, in 1901:

1. The contact of the carbide should be with the water (in other words, the machine should be of the drop type).
2. The carbide should be fed into the water in proportion to the consumption of gas.
3. The gas pressure at the point of delivery should remain practically constant, irrespective of the number of jets burning, or of the amount of carbide, or of gas, in the generator.
4. The pressure should be equal in all parts of the machine and should not exceed that exerted by a 6-inch column of water.
5. When the lights are turned out the generation of gas should cease.
6. The gas should be delivered to the burners clean, cool, and dry.
7. The heat of generation must not exceed 200° F.

8. When the generator is recharged there should be no escape of gas.

9. If the generator is left idle for a long period there should be no deterioration of the carbide.

10. The gas holder attached to the generator should be of ample capacity and made tight with a water seal.

11. The pressure in the service pipe should never exceed that of a 3-inch column of water, and a provision must be made to blow off into the air at a pressure of 6 inches.

12. The water capacity of the generator must be at least 1 gallon of water to 1 pound of carbide.

13. There must be a convenient method of getting rid of the slaked carbide without escape of gas.

14. The generator must be entirely automatic in its action. That is to say, after it has been charged it will need no further attention until the carbide is entirely exhausted.

15. There should be a simple method of determining the amount of unconsumed carbide in the generator at any time.

16. The generators should be so simple in operation that they can be tended by unskilled labor without danger of accident.

17. The various operations of discharging the refuse, filling with fresh water, putting in carbide, and starting the generator should be so arranged that it is impossible to do them in the wrong order.

18. The generators must be so arranged that there can be no possibility of mixing air with acetylene gas.

19. Generators must be built of substantial materials well adapted to their purpose.

20. Generators must be so constructed that an addition to the charge of carbide can be made at any time, without affecting the light.

Any generator that is built according to the preceding points may be considered excellent.

51. Materials of Construction.—Generators should not be made of tin, but should be of galvanized sheet iron, not less than No. 20 gauge, but No. 22 gauge may be used in bell constructions, where stiffening rings are provided.

Seams should be either locked or riveted, as well as soldered. Seams that are only soldered are liable to open up if a fire occurs near the apparatus, and this, in the case of an automatic-feed generator might result in the lowering of the bell through leakage, and a consequent large production of gas at a time when it would produce most harmful results.

All braces, pipe hangers, etc. should not be secured by bolts but rather by rivets, and the heads of these should be soldered over to avoid any chance of a leak. All pipe connections should be of standard galvanized-iron pipe. Where pipes run through the sheet metal, either a flange, with a standard pipe thread tapped into it, should be riveted or soldered on, or malleable locknuts should be soldered on each side of the sheet metal. Pipes should run through sheet metal at right angles to it.

Right-and-left couplings properly made up are better than flange unions or packed unions, ground unions, or long screws.

Where flanges are necessary, the best pure rubber packing, not less than $\frac{1}{8}$ inch thick, should be used.

The pipe connections should be as simple as possible and the minimum number of valves and fittings should be used.

The height of the gas holder should be about the same as its diameter; the size should be such that when no gas is being generated and the machine is feeding the maximum number of lights for which it is rated, the bell will descend at the rate of not more than 3 inches per minute. The bell should be guided either by a central guide post or by side columns on the same principle as the ordinary large gas holder. Just before the bell can reach its maximum height an automatic blow-off should open into the waste pipe that runs to the outside of the building. In this way all danger of the gas holder getting too full and allowing gas to blow out into the room will be avoided. The inlet and outlet pipes should be separate and placed as far apart as possible. Variation of pressure in the house pipes, due to the too rapid production of gas in the generator, will thus be avoided, and the gas will have a better chance to cool and deposit some of its moisture.

The space in a machine that contains air when starting up should be made as small as possible.

No copper should be used in any part of the construction of an acetylene machine.

In the presence of some of the impurities found in acetylene, a substance known as **acetylide of copper** is formed. This product belongs to that class of substances known as **fulminates**, and in common with them it can be exploded by a sharp blow, or by friction.

52. Selecting a Machine.—No machine should be installed that is not approved by the Fire Underwriters. This precaution is necessary to prevent the cancelation of fire-insurance policies on the property in which the machine is installed. The National Board of Fire Underwriters issues a list of acetylene-gas machines approved by them, a copy of which may be obtained from the Board on application. The address of the Board can be obtained from any reputable fire-insurance agent.

53. To intelligently select a good acetylene-gas machine, it is advisable to first secure the Fire Underwriters' latest list of approved machines, and then to send for the manufacturers' catalogues of these machines. The construction and operation of the different machines should then be carefully studied in order to determine which most nearly meets the previously explained requirements of a good machine.

54. Regulations for Operation of Machines.—The following regulations should be observed in the operation of acetylene machines:

1. Calcium carbide should be kept in water-tight metal cans by itself, outside of any insured building, under lock and key, and where it is not exposed to the weather.

2. A regular time should be set for attending to and charging the apparatus during daylight hours only.

3. In charging the generating chambers of water-feed machines, clean all residuum carefully from the containers and remove it at once from the building. Separate from the mass any unslaked carbide remaining, and return it to the container, adding new carbide as required. Be careful never to fill the container over the specified mark, as it is important to allow for the swelling of the carbide when it comes in contact with water. The proper action and economy of the machine are dependent on the arrangement and amount of carbide placed in the generator. Carefully guard against the escape of gas.

4. Whenever charging with carbide, always replenish the water supply.

5. Never deposit residuum or exhausted material from water-feed machines in sewer pipes or near inflammable material.

6. Water tanks and water seals must always be kept filled with clean water.

7. Never install more than the equivalent of the number of half-foot burners for which the machine is rated.

8. *Never test the generator or piping for leaks with a flame, and never apply flame to an outlet from which the burner has been removed.*

9. *Never use a lighted match, candle, lantern, or any open light near the machine.*

10. See that the entire installation is in accordance with the rules of the National Board of Fire Underwriters, and obtain a written guarantee that these rules are complied with.

Failure to comply with these regulations is liable to endanger life and property.

55. Machines Subject to Frost.—Since water is used in acetylene generators and gas holders, they should be installed in places where the temperature will not go below the freezing point. Where this is impossible, the water drawn from the generator with the residue should be allowed to stand in a tank or barrel until the lime has settled out of it. The clear water may then be put back in the machine and will not freeze above zero. Ten per cent. of glycerine added to the water in a gas holder will prevent freezing under ordinary conditions. Stoves or fireplaces must never be permitted in the same room with the generator.

The generator room may be safely heated by hot water or steam pipes.

56. Cost of Acetylene.—Calcium carbide varies somewhat in cost, being generally about 4 cents per pound delivered in small quantities on the consumers' premises. Since 1 pound of calcium carbide will produce at least 4½ cubic feet of acetylene, the cost may be reckoned at a little less than 1 cent per cubic foot, assuming carbide to be 4 cents per pound. The cost, therefore, for each ordinary half-foot burner, will be about ½ cent per hour for a 20-candlepower flame. Ordinary city gas at $1.50 per thousand cubic feet costs ¾ cent for each open flame burning 5 cubic feet per hour. City gas is usually about 20 candlepower, so that it would require one 5-foot burner to give as much light as a ½-foot acetylene burner. When used with Welsbach lights, however, city gas gives about 20 candlepower per cubic foot, so that a light burning the usual quantity of gas, about 3½ cubic feet per hour, would produce about 70 candlepower at a cost of .525 cent per hour.

ACETYLENE BURNERS

57. Plain Burners.—Ordinary gas tips or burners cannot be used for acetylene gas, because with such burners an acetylene flame does not get an air supply sufficient for perfect combustion, and consequently smoke will be formed. Moreover, the tip soon becomes so hot that the acetylene is decomposed by the extreme heat, before it is burned, and the candlepower of the flame is lowered, while the tip itself soon becomes choked with soot and carbon, which are produced by the charring of some of the more condensible hydrocarbons.

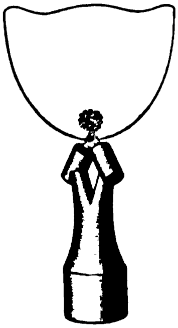
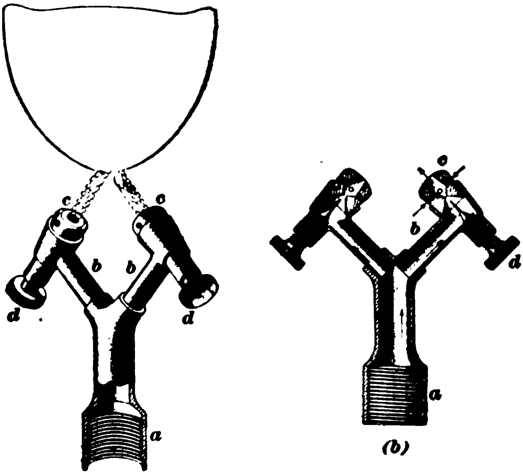


FIG. 12

58. A good acetylene burner is made in the form of a Y. The small jets, one from each branch of the Y, impinge on one another and form a flat flame, as shown in Fig. 12. The two jets are at right angles. Each jet is a miniature Bunsen burner, which draws air along with the gas, so that just enough air is supplied to give smokeless combustion.

The flame itself does not touch the tips, which consequently do not become overheated.

59. Fig. 13 (*a*) shows a **needle burner** in perspective; Fig. 13 (*b*) shows the burner in section. The socket *a* screws on the ordinary gas fixture. Gas flows through the arms *b*, *b* and out through a hole drilled in the center of each of the



(a) (b)

FIG. 13

tips *c*, *c*, as shown by the arrows. Air flows in through a number of radial holes in the tips, as shown by the arrows, and mixes with the gas before it ignites. The needle valve *d* serves to regulate the flow of gas, and can be removed for cleaning purposes. The size of the flame is increased by unscrewing the needle valve. Closing the valve tight not only shuts off the gas, but the long needle point also removes any carbon that may have gathered over the mouth of the central hole. Hence, this burner is self-cleaning.

60. As metal tips are apt to warp, even at the low temperature to which they are subjected, steatite tips are preferable.

61. It is bad policy to turn ordinary acetylene flames down, as the jets then lose their Bunsen effect and are apt to become clogged with soot. Burners that are supplied with a small needle valve regulating each jet may be regulated to burn a very small amount of acetylene with satisfactory results.

62. Incandescent Burners.—The use of acetylene in lamps of the Welsbach type has been frequently attempted and there are several such lamps on the market.

The highest practical efficiency obtained by the use of acetylene burners of the Welsbach type is about 90 candlepower to the cubic foot; a half-foot burner of this type would, therefore, give 45 candlepower, which is a little more than double the light that can be obtained by the open flame.

It has, however, been found that the intense heat is injurious to mantles, and if the use of Welsbach lights is to be made successful it is necessary to remove every trace of phosphureted hydrogen from the acetylene. Otherwise, phosphates of the earth of which mantles are composed are soon formed on the surface of the mantle, and, as these phosphates are readily fusible, the life of the mantle is short.

63. Cooking Burners.—Acetylene cannot be used in gas stoves or ranges such as are ordinarily used for illuminating gas.

Insufficient air supply from the ordinary stove Bunsen burner leads to the stoppage of the burner by soot and carbon, which is made worse by the heat of the burner decomposing the gas. In addition to this, the burner becomes hot, and, in consequence of its low ignition temperature, the mixture of acetylene and air ignites below the burner, or in other words, flashes back.

Suitable burners, however, can be constructed. These have usually a long draft stack below the burner, so that a quantity of air sufficient for proper combustion is added and properly mixed with the acetylene; the area of the burner surface is arranged in such a proportion to the amount of gas to be consumed that the burner does not become hot enough at any point to cause flashing back. Stoves equipped with such burners are on the market, but their operation is much more expensive than that of ranges using ordinary illuminating gas. This is due to the fact that while acetylene gives ten times as much light, volume for volume, than ordinary illuminating gas, the number of heat units developed is only about threefold. Thus, a range burner consuming 15 cubic feet of illuminating gas per hour, at $1.50 per 1,000 cubic feet, costs 2¼ cents per hour, while an acetylene burner, to develop the same amount of heat, consumes 5 cubic feet per hour, which with acetylene at 1 cent per cubic foot, costs 5 cents. Where acetylene is at hand, however, the convenience of gaseous fuel will in many cases lead to the use of acetylene stoves.

ACETYLENE FOR GAS-ENGINE USE

64. Gas engines may be operated by acetylene gas under suitable conditions, but, since the economy of a gas engine depends very largely on the degree of compression to which the mixture of gas and air in the cylinder is subjected before it is exploded, the economy of the acetylene-gas engine must be less than that of the ordinary gas engine.

The compression of the charge in the engine generates heat, and, consequently, the compression in the cylinder of an acetylene-gas engine must be so low that the temperature of ignition will not be reached before the proper time for an explosion occurs. For the same reason the cylinder of the engine would have to be water-cooled sufficiently to keep the temperature always below the igniting point.

Supposing, however, the same efficiency in relation to the comparative heating values of acetylene and illuminating gas could be obtained, the operation of the engine would still be more than twice as costly as with illuminating gas for the same reason that makes the use of acetylene stoves more expensive; 20 cubic feet of ordinary illuminating gas will develop 1 horsepower in a gas engine, and at $1.50 per thousand cubic feet this costs 3 cents. An acetylene engine to develop 1 horsepower, according to the relative number of heat units, would use about 7 cubic feet of gas, and with acetylene at 1 cent per cubic foot, this would cost 7 cents. On account of the low igniting temperature, it would be difficult to use a hot tube igniter on an acetylene-gas engine, but an electric igniter could be used.

PIPING FOR ACETYLENE GAS

65. Size of Pipes.—The pipes used for distributing acetylene gas need not be as large as those used for ordinary illuminating gas, because of the much smaller volume of acetylene required to produce the same amount of light. It is not good practice, however, to use pipes smaller than $\frac{1}{4}$ inch nominal diameter. The difference between the cost of this and $\frac{1}{8}$-inch pipe is slight, and $\frac{1}{8}$-inch pipe is easily stopped by any scale or rust that may be in the pipes. When acetylene gas is piped into a house from the street, the service should never be less than $\frac{3}{4}$ inch, as $\frac{1}{2}$-inch pipes are very easily distorted; the same care should be used, with regard to the drainage of the piping system, that is observed in laying an ordinary piping system for illuminating gas.

Where acetylene is distributed through mains in the streets, the diameter of the mains may be reduced to one-half that of the mains for ordinary illuminating gas, but no street main should be less than 1-inch pipe.

Drips must be installed at the low points on the mains, just as in ordinary gas practice. The best wrought-iron pipe should be used, and screwed joints should be made in all cases. The mains should be very carefully tested under pressure, for leaks, before being covered.

66. Acetylene Leakage. — Leakage in an acetylene system is even more serious than in the case of illuminating gas. If an ordinary illuminating-gas company sending out 1,000,000 cubic feet per month has a leakage of 50,000 cubic feet in the same period, the leakage would be only 5 per cent., but an acetylene gas company supplying the same amount of light would send out only one-tenth as much gas, or 100,000 cubic feet, and if the leakage remained the same, that is, 50,000 cubic feet, it would be 50 per cent.

67. Acetylene Meters.—Ordinary dry meters may be used for metering acetylene and should be rated at 15 times their normal capacity. Thus a three-light meter will supply 45 lights.

ACETYLENE GASWORKS

68. In installing an acetylene gasworks it is best to put in a gas holder and a generator of such size that it will never be necessary to generate acetylene at night. A station meter, which may be of the ordinary dry type, should always be installed, as otherwise a careful record of the operation of the plant cannot be maintained. Automatic carbide-feed generators are sometimes used for such plants, but, as an attendant should always be at hand, the simpler hand-feed generators are more frequently used.

In this case the production of gas is somewhat intermittent, and it is best to install a small relief holder to take up the fluctuation so that the gas passes through the meter at a regular rate of speed. The plant should be heated in winter by steam or hot-water coils, and the heater should be placed in a separate building away from the generator house.

ACETYLENE LAMPS

69. Acetylene Street Lamps.—Acetylene is very suitable for street lighting, as the flame is not easily blown out, but suitable globes and wind guards should be placed on all lamp posts.

On account of the compact generating apparatus that may be used, and the fact that a stock of carbide sufficient to produce a large amount of acetylene can be readily carried, acetylene is very suitable for the lighting of cars, boats, etc. Car lighting is also accomplished by means of acetylene carried under pressure in tanks in the same manner as Pintsch gas, but the dangers resultant from the use of acetylene in this way have prevented its general application. When such tanks are carried they should always be provided with fusible plugs, so that in case of fire the plugs will melt and the acetylene escape and burn, instead of exploding from overheating.

70. Acetylene Portable Lamps.—On account of the difficulty of proper regulation of the production of acetylene and consequent regulation of the pressure, portable lamps have not come into general use.

71. Fire Underwriters' Requirements for Portable Lamps.—The Fire Underwriters require that a portable acetylene lamp must be made in compliance with the following rules:

1. Lamps must be substantially made of metal, and the construction must embody no copper, either pure or alloyed, in contact with acetylene.

2. Lamps must be, in all parts subject to corrosion, thoroughly protected by an effective and durable preventive of rust.

3. Lamps must be designed with a view to stability, the assembly being such that when completely charged and ready for operation, inclination at an angle of 30 degrees with the vertical will not result in upsetting.

4. Lamps must be fitted with not more than one single or multiple burner, and the total rated gas consumption shall not be more than ¾ cubic foot per hour.

5. Lamps must be automatically regulated and uniform in their action, producing gas only as immediate consumption demands, and be so designed that gas is generated without producing sufficient heat to cause yellow discoloration of the residuum (which will occur at about 500° F.) or abnormal pressure at any stage of the process, when using carbide of any degree of fineness.

6. Lamps must have no mechanical or spring relief valves, and must be designed so as to prevent automatically the accumulation of excessive pressure when placed in any position or overturned.

7. No valves or petcocks opening into the room from gas-holding parts, the draining of which would allow an escape of gas, are permissible, and condensation from all parts of the apparatus must be automatically disposed of without the use of valves or mechanical working parts.

8. Gauge glasses, the breakage of which would allow escape of gas, must not be used.

9. The use of mercury seals is prohibited. Mercury has been found unreliable as a seal in acetylene apparatus.

10. Combustible oils must not be used in connection with the apparatus.

11. Water seals, the breakage of which would allow escape of gas into the room, are prohibited.

12. Every lamp must be provided with a permanent marking, stating plainly the amount of carbide necessary for a single full charge, and the manufacturer's name and name of the lamp.

13. The generating chambers must be so designed that generation will take place under conditions similar to those that obtain in the best generator practice.

14. Generators must afford ample room for the residuum without containing unnecessary air spaces.

15. Generators must be so designed that the residuum will not clog or affect the working of the device, and be so arranged that the residuum can conveniently be handled and removed.

16. The carbide receptacles must have sufficient carbide capacity to supply continuously the burner for which the lamp is rated during a lighting period of not less than 6 hours.

In determining charges, the yield of gas from the various grades of carbide shall be estimated as follows:

From the 3½" to the 2" grade, 4½ cubic feet per pound.

From the 2" to the ½" grade, 4½ cubic feet per pound.

From the ½" to the ¼" grade, 4½ cubic feet per pound.

From the ¼" to the $\frac{1}{12}$" grade, 4 cubic feet per pound.

From the Electrolite grade, 4 cubic feet per pound.

These figures are specified in order that a reasonable allowance may be insured for depreciation after the initial opening of the package. The gas consumption of burners shall be estimated at 50 per cent. in excess of the rating.

17. Carbide receptacles must be arranged so that the carbide holders, or charges, may be easily and entirely removed in case of necessity.

18. Carbide receptacles may in no case have capacity for more than 2 pounds of carbide.

19. The water supply must be similar in quantity to the allowance made in the best generator practice.

20. The working pressure at the burner must not vary more than $\frac{10}{10}$ (1) inch water column under all conditions of carbide charge and feed.

21. Lamps requiring pressure regulators or reducers must be so constructed as to withstand without injury a pressure equivalent to four times the maximum pressure obtainable in normal operation.

22. Pressure regulators must conform to the rules for the construction of other acetylene apparatus so far as they apply and must not be subject to sticking or clogging.

23. Pressure regulators must be capable of maintaining a uniform pressure, not varying more than $\frac{4}{10}$ inch water column, at any load within their rating.

24. Where installed, purifiers must conform to the general rules for the construction of other acetylene apparatus and allow the free passage of gas.

25. The means of control must be such as to obviate accumulation of pressure within the lamp or appreciable discharge of gas after extinction of the light.

26. The means of control must be so arranged as to necessitate a tight closure of the carbide filling opening before the feed can be put into operation.

GASOLINE GAS

PROPERTIES

72. **Gasoline gas,** or **carbureted air,** also called **air gas,** is a mixture of gasoline vapor with air. The pure vapor is so rich in carbon that, in order to burn it successfully for lighting purposes, it must be given a high pressure; and special burners must be employed, as for acetylene. In order to burn it in the same burners used for illuminating gas and at the same pressure, it must be diluted with air until the proportion of carbon equals that in ordinary coal gas.

The air furnishes a part of the oxygen required for combustion, but it also introduces a large proportion of nitrogen, which is inert and useless material, being incombustible; the nitrogen reduces the temperature of the flame and thus diminishes its brilliancy.

Gasoline is produced by distilling crude petroleum. Its specific gravity averages about .75 that of water. It is really a mixture of a large number of hydrocarbon compounds that differ slightly in their chemical proportions. All of them, however, will change from the liquid to the gaseous form, under ordinary atmospheric pressure, at a temperature ranging from 70° to 100°. If a tank containing liquid gasoline is opened to the air, the liquid will all pass away in the form of gas. The rapidity of the evaporation will depend on the temperature, being very slow at 40°, quite rapid at 70° and furious at 212°; and, if the liquid catches fire in any way, it will pass into gas with explosive violence. The burning liquid expands enormously and is very difficult to extinguish. Gasoline must be regarded as gas in a liquid form, and it should be clearly understood that it will resume the gaseous form whenever the opportunity is afforded. The effect of leaving a can of gasoline uncorked is exactly the same as that of leaving a gas cock open; in both cases the gas will diffuse through the atmosphere and form explosive mixtures.

It is generally regarded as a dangerous material to use or handle, but the danger arises from the recklessness or neglect of the persons using it. If the same care is taken to keep it shut up as is taken to keep coal gas confined, it is no more dangerous than the latter. A tank of gasoline should be treated as a reservoir of gas.

73. There are different grades of gasoline in the market, which differ in their specific gravities. A gasoline called **crude naphtha** has a specific gravity of .6, and is used for making illuminating gas. For cooking stoves, for plumbers' torches, and for firepots, gasoline having a specific gravity from .7 to .74, is adapted. For use in gas engines, as in automobiles, a gasoline having a specific gravity of .74 is used. For gas machines the specific gravity should be .86 for the summer and .88 for the winter. The highest grade is sometimes called **winter gasoline**; its specific gravity is about .9. This grade will evaporate at ordinary temperatures and leave nothing behind. The poorer grades contain more or less oil that will not evaporate without the aid of heat; this oil collects in the gas-generating apparatus, and must be removed from time to time. It is usually thrown away, but it is very similar to low-grade kerosene, and will burn in the same manner in gasoline stoves.

It has become the custom in the trade to designate the specific gravity of gasoline in per cent., water being considered as 100. Thus, when an 86-per-cent. gasoline is mentioned, a gasoline having a specific gravity of .86 is meant.

74. The quantity of gasoline that is required to produce 1,000 cubic feet of gas, and that will give a light of 14 to 16 candles (when burning at the rate of 5 cubic feet per hour), is about 4½ gallons of the best grade but more is required if the gasoline is of a lower grade.

GASOLINE-GAS MACHINES

75. Generator.—The apparatus used for making illuminating gas from gasoline consists of three parts: a *generator* for holding the gasoline, an *air pump* for forcing air through the generator, and a *mixing device* for mingling the air and vapor in proper proportions.

The vapor is made by simple evaporation, without the aid of heat. The liquid is spread out in large shallow pans, and the air is compelled to pass successively over its surface in all the pans. The construction of the evaporator, or **generator,** is shown in Fig. 14. Three pans *a*, *b*, and *c*, and sometimes more, are employed, and all are enclosed in a gas-tight casing having an opening *i* in the side for the inlet of air and another opening at *d* for the outlet of gas. Some parts of the gasoline evaporate slowly, and it is necessary to have large evaporating surfaces, so that a proper amount of vapor will be given off when the lighter parts of the liquid have been evaporated and only the heavier parts remain. In order to increase the evaporating surface, the pans are partly filled with cotton or similar porous materials which absorb the gasoline, and the air is forced to pass partly through the mass of absorbent material. A common practice is to arrange some capillary material woven into a coarse fabric in the zigzag manner shown, so that the air will be compelled to flow through the meshes of this netting, and thereby absorb the gasoline that is drawn up by capillary attraction.

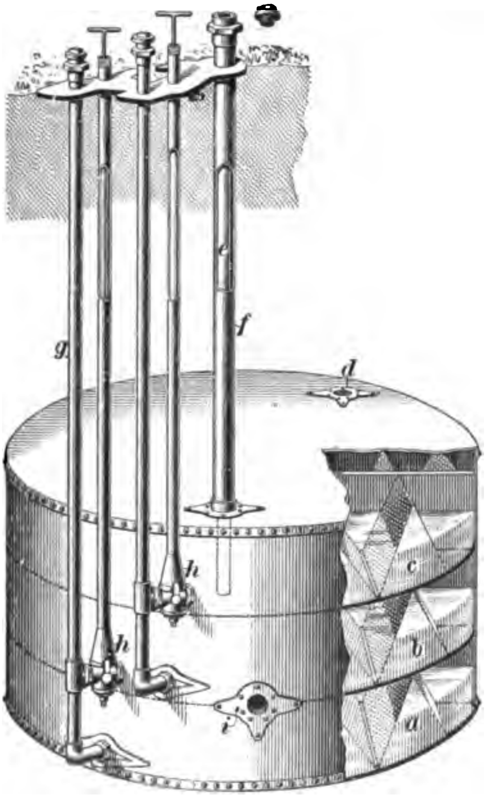


Fig. 14

The generator is charged by pouring the gasoline down through the pipe *e* into the upper pan *c*. The pipe *f* through which *e* is slipped forms an outlet tube for air while the generator is being filled with gasoline. When this pan becomes full, the liquid overflows into the next pan below, and thus they are all filled successively. Should the bottom pan become too full, the excess may be pumped out by attaching a pump to the top of the tube *g*.

When the lighter parts of the gasoline have been evaporated from any one pan, the remainder is usually dropped into the next pan below by opening one of the cocks *h*. The waste liquid collects in the bottom pan and may be removed from time to time by pumping through the tube *g*.

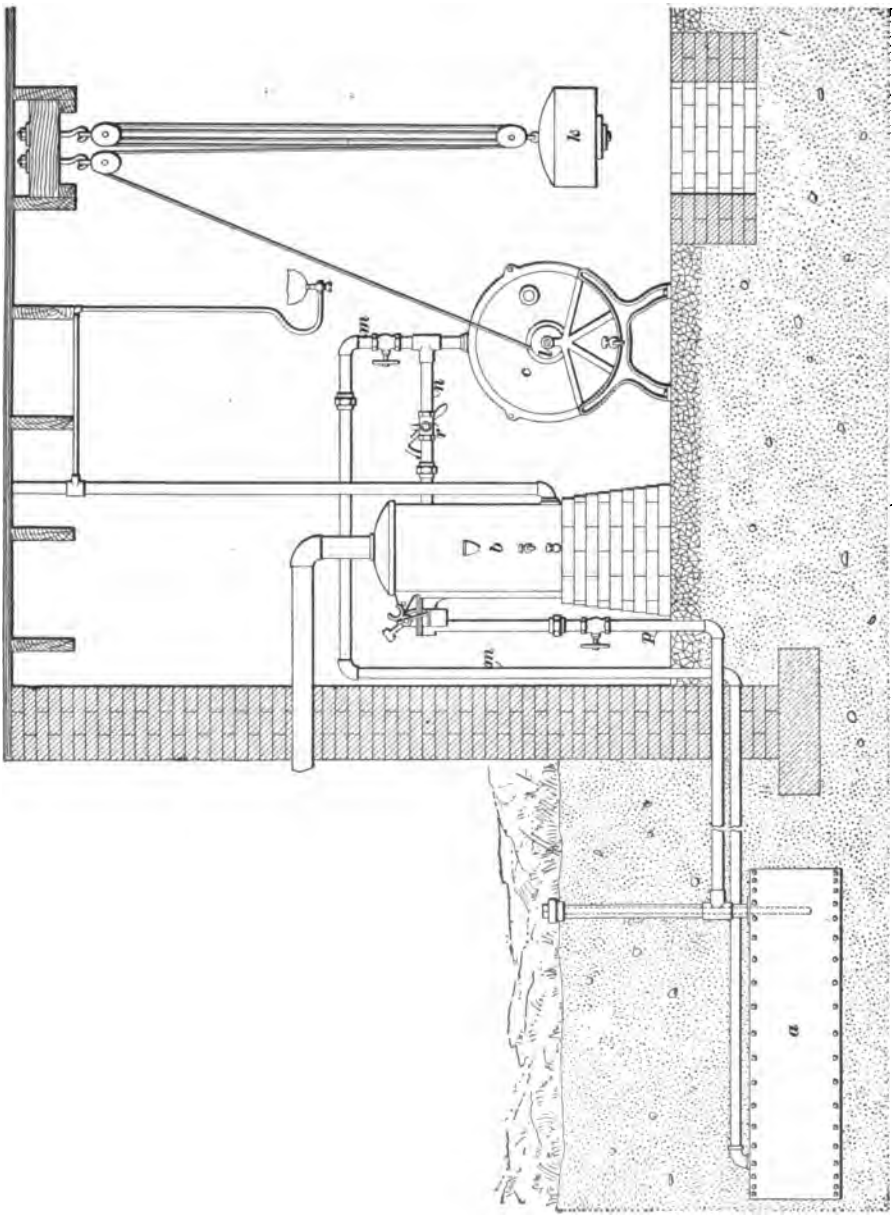


FIG. 15

The generator is buried in the earth outside of all buildings, for fear of possible explosions. It must be buried deep enough to avoid all risk of freezing, because at temperatures below 32° the liquid evaporates too slowly to answer the purpose. The handles of the valves and all the pipes needed for testing and filling are extended upwards to the surface of the ground, and are protected from the weather by a suitable water-tight box and cover. It was formerly customary to place the generator in an underground vault. The advantage of this arrangement was that the generator was fully accessible; but the construction of the vault increased the total cost of the apparatus so much that the plan has been nearly abandoned. The buried generators need to be strongly built to stand the pressure of the earth around and above them.

76. Air Pump.—The **air pump** may be of any suitable design; the kind commonly used is shown in Fig. 15. It closely resembles the wet gas meter in construction and principle, except that the drum is rotated by power so as to act as a force pump instead of as a meter. The drum is turned by means of a heavy weight *k* and a cord that is wound around the pulley *l*. It turns very slowly, even when working at full speed. The weight is required to be wound up at intervals of three to four days or more, according to the demand for gas.

The pump should take air from some place that is never at a freezing temperature, because cold air will check evaporation in the generator.

The body of the machine is filled with water up to a certain mark, which is usually visible through a mica bull's eye. The water evaporates slowly, and must be replenished from time to time. The air is driven through the pipe *m* to the generator *a*, and returns mixed with vapor through the pipe *p*.

When the gasoline is cold, or is nearly spent, it is necessary to change the proportions of the air and vapor in order to maintain the illuminating power of the gas at the standard desired. Otherwise, the gas will be too rich, that is, it will contain too much carbon; consequently, it will smoke in summer time, and will burn pale and blue in very cold weather. This difficulty is sometimes met by using adjustable burners, but the drawback to that arrangement is that all the burners must be adjusted at intervals to suit the varying quality of the gas.

If a mixing device is used, then all the necessary adjustments can be made at one point, and ordinary Batswing burners may be used without any trouble.

77. Mixing Device.—The **mixing device** consists of a by-pass pipe *n*, Fig. 15, connecting the air pipe *m* with the gas pipe *p*. It is provided with a cock *r*, having an index and pointer, by which it can be adjusted to any desired amount of opening. The mixing device is not automatic, but must be adjusted by hand.

When the apparatus runs very slowly, or stands still for a while, the gasoline vapor, with a direct connection, will diffuse throughout the pipes *m* and *n* and back into the pump. The mixer is then useless. This trouble may be prevented by means of the regulator shown in Fig. 16, which is an enlarged sectional drawing of the regulator *b* in Fig. 15.

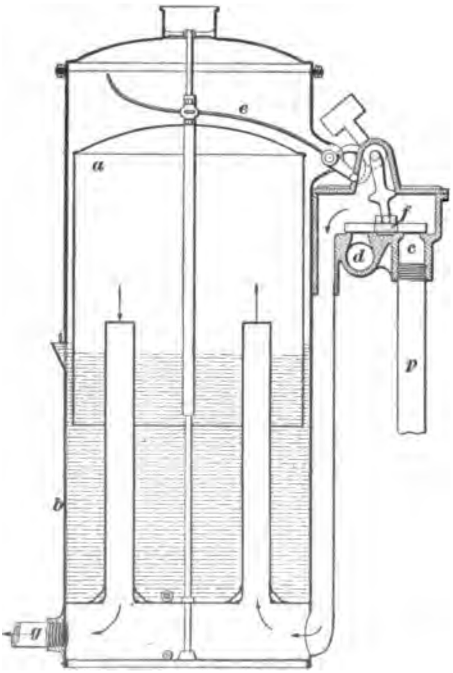


Fig. 16

The gas coming from the generator is introduced at *c*, and the air from the by-pass pipe is brought in at *d*. Both openings are controlled by a slide valve *f*. The gas is discharged into the distributing pipe at *g*. When gas is passing through the machine, the drum *a* alternately fills and empties, rising and falling in the water tank *b*.

When it rises, it fills with gas from *c* and fresh air from *d*, according to the adjustment of the by-pass cock. When it reaches the top of its stroke, it moves the lever *e* and closes the valve *f*. The mixture within the drum is thus cut off from all communication with the generator or the pump; consequently, its proportions cannot be changed by standing for any length of time. When the drum sinks to the bottom of its stroke and is nearly empty, it moves the lever *e* in the opposite direction, and opens the valve *f*, thus admitting a new charge. The water in the tank gradually evaporates when the machine is in use, and it is necessary to replenish it occasionally.

78. Effect of Poor Gasoline.—When a poor grade of gasoline is used in making the gas, the generator gradually becomes clogged with an oil that will not evaporate freely and that for the purpose of gas making is spent and useless. This is generally pumped out and thrown away. It should not be thrown into a drain or a sewer, because it will fill them with explosive gas. It should not be thrown into a stream of water, because of the danger from fire to everything adjoining the water, and because of the stench to which it will give rise. The whole trouble may be avoided by using a better grade of gasoline.

79. Precautions Against Frost.—All the pipes in the gas apparatus, and the house pipes as well, must be kept out of reach of frost, and if they are exposed they must be well protected. The pipes must be graded and drained, and provided with drip cups in the same manner as with coal gas, etc. A low pressure is generally used throughout the system of distributing pipes, and, therefore, the pipes are usually made a little larger than for coal gas.

80. Gas Machines for Manufacturing Purposes. The apparatus used for making gas from gasoline for manufacturing purposes is very simple. The air is supplied by a common steam pump at a pressure of 3 or 4 pounds per square inch. The gasoline is contained in strong vertical cylinders, which are loosely filled with cotton or other absorbent fibres, and the air is forced through the mass. The temperature of the air is raised a few degrees by the process of compression, and the warmth aids the evaporation of the gasoline. The quality of the gas is maintained at any desired standard, by pumping fresh gasoline into the generator whenever it is required. In some forms of apparatus, the evaporation of the gasoline is aided by the application of a moderate steam heat.

When gas is formed by the aid of heat, care must be taken to prevent it from cooling to any considerable extent, because a part of it will then condense into liquid form again.

NATURAL GAS

81. Natural gas is obtained from holes or wells that are drilled in the earth. It is found in large quantities in the vicinity of deposits of petroleum; and deposits of coal, both bituminous and anthracite, are always accompanied by greater or less quantities of gas of a very similar nature.

It is composed mainly of a compound of carbon and hydrogen, and is called **light carbureted hydrogen.** This often amounts to 90 per cent. or more of the total volume. Consequently, it will develop more heat per cubic foot in burning than any other kind of gas except acetylene.

Natural gas is produced at the wells under great pressure, and in common practice the pressure in the street mains and distributing pipes is allowed to be very much higher than is usual with manufactured gas.

GAS SUPPLY AND DISTRIBUTION

(PART 1)

GAS SUPPLY

GAS PIPES AND FITTINGS

CAST-IRON GAS PIPE

1. Definitions.—The pipes used for the distribution of gas are made of different materials, such as cast and wrought iron, brass, lead, block tin, and composition (which is an alloy of lead, tin, and antimony); they are also made of rubber.

The main gas-supply pipes that are laid in the streets are called **mains.**

Branches that conduct gas from the mains to the house are called **service pipes** or **services.**

Pipes that convey the gas from the meter to the various parts of the building are called **distributing pipes.**

Vertical pipes are called **risers** or **drop pipes,** according to the direction of the flow of gas within them. The flow is upwards in a riser, and downwards in a drop pipe.

2. Properties and Sizes.—Cast iron is usually employed for large pipes that are to be buried in the ground, such as street mains and service pipes. The pipes made of this material are liable to be of uneven density and texture, being close grained and hard in some parts, and coarse grained and spongy in others. They are liable, also, to be

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perforated by blowholes and bubbles, which vary in size from minute pinholes to hollow spaces as large as the hand, having only a thin crust of metal on the inside and outside of the pipe. To detect these defects, all cast-iron pipe should be thoroughly inspected at the foundry where made. The presence of unsound iron or spongy places, or bubbles of any considerable size, will be revealed by the difference in the sound when tapped with a light hammer. Each pipe should also be subjected to a test by hydraulic pressure, to prove its tightness and strength.

3. If the grain of the iron be coarse and soft, the gas will gradually exude through the metal and leak away, although the pipe may be strong and solid. While this defect can be remedied in water pipe by coating the pipe thoroughly both inside and outside with asphaltum or a mixture of asphaltum and tar, such a coating is useless for gas pipe, as the gas will dissolve the tar or asphaltum and then leak out. Such a coating on gas pipe is of value only in preventing rust; in the case of cast-iron pipe, such a precaution is unnecessary in ordinary soils.

Where coated pipe is used, the proper method of applying the coating is to dip the previously tested pipe while hot in a bath of melted asphalt or tar. If the metal is not properly heated, the coating will not adhere with sufficient firmness and will fail to penetrate and seal the small defects in the pipe. The standard cast-iron gas pipes on the market are usually uncoated.

When coated pipe is used for gas mains, both the bell and spigot ends should be heated in a fire until all the tar or asphaltum has been burned off; for, if the joint is made up with the coating on, the gas will dissolve the thin film left between the pipe and the lead or cement used to make the joint; and a leak will occur.

4. The standard sizes and weights of cast-iron gas pipe are given in Table I, taken from Kent's Mechanical Engineers' Pocketbook. The standard length of all sizes is

12 feet, excepting 2-inch pipe, which is 8 feet long. The size of cast-iron gas pipe is designated by the actual internal diameter.

TABLE I

STANDARD CAST-IRON GAS PIPE

Size in Inches	Weight Per Foot Pounds	Weight Per Length Pounds	Thickness Inches
2	6	48	$\frac{1}{4}$
3	$12\frac{1}{2}$	150	$\frac{5}{16}$
4	17	204	$\frac{3}{8}$
6	30	360	$\frac{7}{16}$
8	40	480	$\frac{7}{16}$
10	50	600	$\frac{7}{16}$
12	70	840	$\frac{1}{2}$
14	84	1,000	$\frac{9}{16}$
16	100	1,200	$\frac{9}{16}$
18	134	1,600	$\frac{11}{16}$
20	150	1,800	$\frac{11}{16}$
24	184	2,200	$\frac{3}{4}$
30	250	3,000	$\frac{3}{4}$
36	350	4,200	$\frac{7}{8}$
42	417	5,000	$\frac{15}{16}$
48	542	6,500	$1\frac{1}{8}$
60	900	10,800	$1\frac{3}{8}$
72	1,250	15,000	$1\frac{1}{2}$

5. Trenches and Drip Pot.—Gas mains and service pipes are generally placed in trenches dug to receive them. In order to afford room for working at the joints, holes must be excavated wherever a joint occurs, that is, at intervals of 12 feet for all sizes of pipe above 2-inch, and 8 feet apart for 2-inch pipe. These holes are known as **bell holes.**

The ground between the bell holes should be leveled smooth to carry the weight of the pipe evenly; where the soil is soft or marshy, pieces of board should be placed across the ditch to help carry the weight of the pipe. If it is necessary to fill the ditch any in order that the pipe may be firmly bedded, the earth under the pipe should be tamped thoroughly. If the above precautions are not taken, the pipe may settle and broken mains or leaky joints may result; also, the pipes may sag so as to form a trap in which water will collect and partially or entirely shut off the flow of gas.

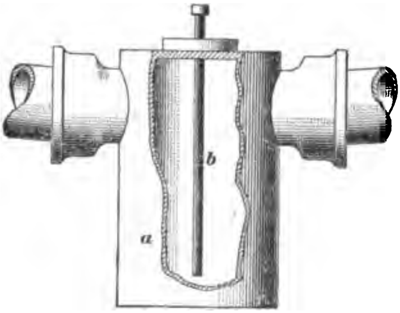


FIG. 1

6. All gas mains must be laid truly level, or else sloping definitely in one direction or the other, and at every low point a **drip pot** must be set. Fig. 1 shows an ordinary drip pot. This is composed of a large iron vessel *a* about the size of a barrel. A small pipe *b* is run from the top of the ground down inside the pot, so that the condensation that is sure to accumulate can be pumped out.

7. Joints.—Cast-iron gas pipe is jointed either by *lead joints* or *cement joints*, lead joints being most commonly used.

A **lead joint** in a gas main lying in a trench is shown in Fig. 2. To make the joint, the spigot end of the pipe is

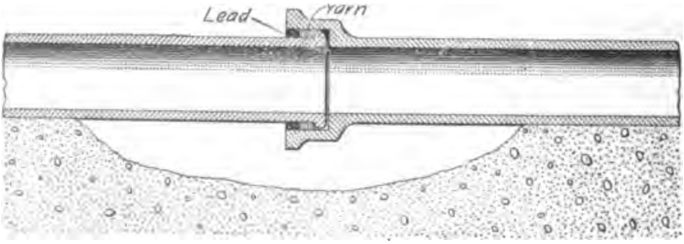


FIG. 2

lifted up after it has been placed into the **bell,** as the socket is often called, of the next length of pipe. A piece of twisted hemp, about $\frac{3}{4}$ inch in diameter and a little longer than the circumference of the pipe, is pushed into the bell in such a way that it completely surrounds the spigot end. The spigot end is then pushed home in the bell and the hemp is driven back solidly around the pipe with a yarning iron or staving tool. More yarn is then driven in around the pipe until only about 1¼ inches of the bell is left clear. A joint runner is now clamped around the pipe close to the bell, and any openings between it and the bell are closed up with clay. An opening or pouring gate is left at the top, through which melted lead is poured until the bell is completely filled. The lead should be just hot enough to run freely and should be poured in from an iron ladle large enough to run the whole joint at one pouring. When two ladlefuls are required, a second ladle should be held ready to begin pouring the instant the first one is empty, to insure a proper adhesion of the lead in the bell. If no joint runner is at hand, a piece of yarn coated thickly with tough clay forms a very good substitute. Such a joint runner is frequently called a **snake.** Where the pipe is a little wet, some oil, such as machine oil, should be poured into the joint before it is run. This will prevent the spattering of lead and will insure a good joint. The lead will cool in 2 or 3 minutes. The joint runner should then be removed and the joint examined carefully, especially at the under side. If the lead has not run in evenly all around and filled the joint properly, it should be cut or burned out and a new joint run.

If the joint has filled out nicely, the lead should be cut with a cold chisel where it may have run out in small leaks, and at the top, where a large block will be left at the point the lead was poured in. The lead should then be driven back all around at the junction of the pipe and lead with a cold chisel and a short heavy hammer, and then the whole surface of the lead joint should be driven up evenly and smoothly with a hammer and a calking iron. Calking irons are made with faces of different sizes, to facilitate the calking of joints of different widths.

Great care should be taken in calking to make thoroughly tight joints, as bad joints are a prevalent cause of leakage.

8. Cement joints are made as follows: After placing the cast-iron gas pipes in the trench, and tamping the ground around them thoroughly so that they cannot settle or be moved out of alinement, as much of them as possible is covered without allowing dirt to fall into the bell holes, and after the pipe layers are far enough ahead of the joint makers, the making of cement joints can be begun.

The cement is made by mixing Portland cement with water, making up just enough cement for two or three joints at a time if there is but one man making joints. The mixing should be done by a helper, who should keep the mixture stirred constantly to prevent initial setting. No sand should be used, only the clear cement, and it should be used in a plastic condition.

In making the joint, the yarn should be first soaked in thin cement and then driven back in the bell and followed up immediately with the cement, which is placed in the bell and pushed back with the right hand. The hand should be protected by a rubber mitten, because cement is injurious to the hands. Cement cannot be pushed back successfully with a trowel or other such tool.

It is useless to put on more cement than is required to just fill the bell, and it should be faced perfectly smooth with a trowel. The joint should be immediately covered with a wet cloth to supply the cement with moisture to prevent it from setting too quick, and to keep the temperature low. By covering the pipes with dirt previous to making the joints, and by boarding over the joints, the temperature of the pipe line does not change sufficiently to injure the joints. If the day is hot, and the sun shines on any part of the pipe or joint, boards should be placed over the joint to intercept the sun's rays.

9. Tests for leaks should not be applied until at least 3 hours after the joints have been made. The test should be made with an air pump; the pressure need not exceed ½ pound, as leaks might be made by a greater pressure. After the joints are thoroughly set, they will stand a higher pressure. If the joints are carefully made, as described, the practice which obtains in some localities of having a lead joint on every fourth or fifth pipe to allow for expansion and contraction, need not be followed, as there is little variation of temperature if the pipe is buried under at least 3 feet of cover. If lead joints are used, the leaks will generally be found at these rather than at the cement joints.

The bells of pipes for cement joints should be made at least ½ inch larger than usual in inside diameter to permit of using the hands in manipulating the cement when placed in. The dirt should not be rammed in around the joints until the next day, and the utmost precaution should be used so as not to strike any part of the pipe, as jarring will make new cement joints leak.

Properly made cement joints are absolutely tight, and are so strong that if the pipe and joint be submitted to pressure, the pipe will break rather than the cement joint.

10. Air Test.—New mains should always be tested in short sections by pumping in air until the pressure is ½ pound or more. The air pressure is supplied by a portable air pump. The pressure gauge should be watched closely, and if it indicates any leak by the gradual lowering of the pressure, the leak or leaks may be found by washing the suspected parts with soapy water. The air pressure will blow soap bubbles over the leaks. All leaks must be closed before the trench is filled. The section of main to be tested must be plugged tightly at each end with temporary plugs.

11. Sleeves.—Where two spigot ends have to be connected together, a **sleeve** is used. This is a short piece of pipe large enough to slip over the pipe on which it is used, leaving space enough for making a lead or cement joint at each end.

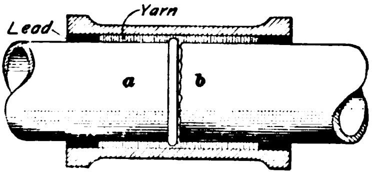


FIG. 3

Fig. 3 shows an ordinary sleeve in section, covering the spigot end *a* of a pipe and the cut end *b* of another pipe. After the ends *a* and *b* are laid face to face, the sleeve is slipped back and calked in place, care being taken to have the same amount of lap over each pipe.

Where a main has cracked, it may be repaired temporarily by winding canvas, painted with white lead, tightly around the cracked pipe. A permanent repair is made by the use of a **split sleeve.** A split sleeve is made up of two halves that are bolted together, as shown in Fig. 4. A gasket of lead, rubber, or pasteboard is put in at *a* to make the flange joints tight. After the split sleeve has been bolted together around the pipe, lead or cement joints are made at each end in the ordinary manner.

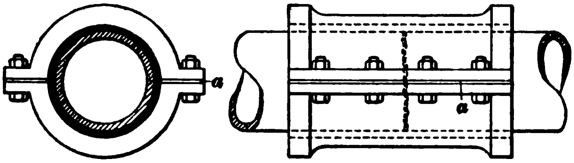


FIG. 4

12. Main Bags.—Where it is necessary for any reason to cut mains on which the gas pressure must be kept up, **main bags,** or main stoppers, must be used to hold back the gas when the main is cut.

13. A main bag is shown at *a*, Fig. 5. It is a round rubber bag with a rubber tube leading out of one side. The bags are made of different sizes to fit the different sizes of pipes in use. Thus, a 4-inch bag, when fully inflated, will entirely fill up a 4-inch main.

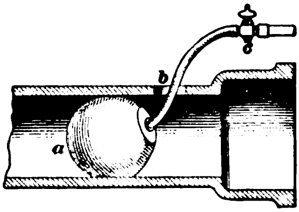


FIG. 5

The bag is used as follows: A hole is tapped in the main, as at *b*, Fig. 5, a few feet from the place where the main has to be cut, with the regular tools used for tapping the main for services.

The hole must be carefully inspected after it has been tapped, and any slivers of metal around the inside edge removed. The bag, which should be fitted with a small cock *c* at the end of the tube, is then folded up and introduced into the hole, the end opposite the tube being pushed in first. The bag should be pushed well into the main, in the direction from which the gas comes, and then inflated either by blowing into the tube, or by the use of a small pump, such as a bicycle pump. In the latter case, care must be used not to burst the bag. When the bag is fully inflated, the cock in the end of the tube is shut. The main will then be shut off so that it may be cut. When a main is so connected that gas may come from either end, a bag must be put on each side of the part to be cut.

If the main to be bagged is larger than 4 inches, two bags should be put in, one ahead of the other, so that if one bag breaks the other will hold. A good plan is to put in a main stopper first, and then a bag nearer the cut.

14. The following table gives the size of the hole to be tapped for main bags in different sizes of mains:

TABLE II

SIZE OF TAPPING FOR MAIN BAGS

Size of Main Inches	Size of Pipe Tap Inches	Size of Main Inches	Size of Pipe Tap Inches
3	¾	10	2
4	1	12	2½
6	1¼	14	3
8	2	16	3

15. Main Stoppers.—A diaphragm of canvas or leather mounted on a wire frame, and that may be collapsed and introduced through a hole into the main in a manner similar to that employed with a main bag, is known as a **main stopper**. Fig. 6 shows such a main stopper in position inside of a pipe. The frame *a* is expanded after the stopper has been pushed inside the pipe, and the diaphragm then shuts off the main.

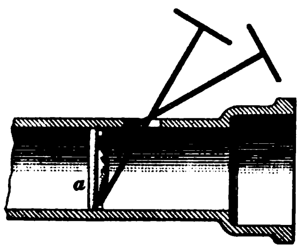


FIG. 6

Main stoppers are not as liable to burst as bags are, but as a rule, they cannot be made to shut off the gas as completely as bags. It is usually necessary to tap a hole one size larger for a main stopper than is tapped for a main bag.

WROUGHT-IRON GAS PIPE

16. Wrought-iron pipe may be used underground if it is thoroughly coated and protected against rust. It corrodes faster than cast-iron pipe under the same conditions, and its durability will depend mainly on the care taken to protect it. The smaller sizes of pipe, such as those employed to connect the house pipes with the street mains, should always be galvanized if they run through damp places, and if buried in the ground, they should also be protected by an external coating of asphaltum or tar, generous in thickness.

When the pipe runs through cinders or coal ashes, the protective coating must be made of extra thickness to resist the corrosive action of the water that filters through the cinders. The pipe should not only be coated with asphaltum in the usual manner, but should also be wrapped with two or more layers of coarse cloth, wound on spirally, and an outer coating of asphaltum applied hot, in sufficient quantity to thoroughly saturate the cloth and cover it.

Galvanizing alone is not a sufficient protection for pipes laid through ashes, or in ground that is permeated with salt or sea water.

Wrought-iron pipe has an advantage over cast-iron pipe, inasmuch as the number of joints required in a given distance is much less. Plain black wrought-iron pipe may be used without hesitation for all the interior piping of a building, except where its appearance would not be desirable. Long lines of wrought-iron pipe of large size should not be laid at a depth of less then 3 feet unless expansion joints are provided at intervals. Otherwise, changes of temperature will cause such strains from contraction and expansion that fittings and couplings may be broken and threads stripped.

LEAD, TIN, COMPOSITION, AND RUBBER GAS PIPES

17. Lead pipe has been used for conveying gas both underground and in buildings, but it is so easily distorted and kinked that iron pipe is now usually preferred. Lead pipe must be protected against corrosion wherever it comes in contact with cement or mortar, by wrapping it with building paper and coating it with asphaltum or hot tar.

18. Pipes that are made of **lead, block tin,** or **composition** have a very smooth interior surface, which favors the flow of gas through them, and they are also capable of being easily bent to suit any position. But, owing to their flexibility, they must be supported on shelving when extended horizontally, to prevent them from sagging and thus forming low places that are liable to accumulate condensation. The labor of making the necessary connections between soft pipes and the fixtures is greater than with iron pipe, and the first cost of the material is also greater; consequently, the use of soft metal piping is usually dispensed with as far as practicable.

Soft metal pipes are liable to be damaged or punctured by nails that may be driven through the woodwork near them, and sometimes holes will be gnawed into them by rats and mice. These little animals seem to like to use their teeth on the soft metal, and they will occasionally gnaw a pipe without any other apparent reason.

In the United States of America, neither lead, block tin, nor composition pipe is today used in any service work or for gas-fitting work inside of buildings, except for meter connections, where lead pipe is generally used.

19. **Pure rubber** is not a suitable material for holding gas, because the gas will ooze through it and escape, just as water will ooze through wet paper. When rubber is used for the construction of gas bags and flexible tubing, it must be specially prepared in order to be gas-tight.

LAYING OUT GAS MAINS

20. In laying out a system of gas mains, a careful estimate should be made as to the probable growth of the locality to be piped, and the mains should then be laid large enough to furnish a proper supply for a long period in the future. The most efficient and best, as well as the cheapest, way to pipe a locality is to lay a large main through it in the direction of its greatest length and to lay smaller lateral mains from the large main on the streets at right angles to it. The streets that parallel the one in which the large main is laid may be supplied by still smaller mains connecting the lateral mains. Then, in case the system is to be extended lengthwise, it is only necessary to extend the large main and put on more lateral mains, while if the locality builds up to the right or left of the large main another large main can be run parallel to the first and at some distance from it and the ends of the lateral mains connected into it.

This system is better than the usual one of beginning with a large main and reducing it in size as the various branches are taken off, thus forming a main system similar to the branches of a tree. In the first place, it is the cheaper in the end, as it obviates the necessity of taking up mains that have become too small and laying larger pipe, and in the second place, it allows a more even pressure all over the district supplied and obviates the necessity of carrying a high pressure near the works.

Where it is necessary to increase the supply in a street, the main that is too small should be taken up and a larger one laid. The small main may then be relaid in some suitable locality. It costs but little more to dig up the old main and lay the new one in the same ditch than it does to dig a new ditch for the new main.

Parallel mains should not be allowed in the same street except in cases where, on account of paving or other reasons, the mains must be laid under the sidewalks. It costs much less to lay one large main of a given capacity than it does to lay two small mains of the same capacity; and, as in the latter case the number of joints will be doubled, the leakage will be greater for the same amount of gas supplied and the cost of repairs and maintenance will be nearly doubled.

Where it is necessary to lay mains on both sides of a street, the best practice is to lay a large main on one side and a small one on the other, connecting the two together at frequent intervals. This is because it is cheaper to lay a large main and a small one of a given capacity than it is to lay two mains of equal size of the same capacity. The small main in the first case, being reenforced at frequent intervals, suffers but little loss in carrying capacity by reason of friction and can therefore be made quite small in proportion to the volume of gas that it is to supply.

GAS-PIPE FITTINGS

21. The fittings employed in gas piping in buildings are generally similar to those made for steam and water, except that some of them are provided with lugs or flanges by which they can be firmly fastened to the walls and ceilings.

They should be made of malleable iron for all sizes up to 2 inches diameter; for larger sizes, cast iron may be used. Galvanized fittings are to be preferred to plain iron fittings, because the coating of zinc will usually penetrate into any small pinhole that may exist, and will effectually seal it against leakage.

Defective fittings should not be employed in any case, and when one is discovered in use, it should be promptly removed, if possible, and be replaced with a perfect one. The practice of patching holes or defects in fittings or pipes with wax cement is dangerous, and should be condemned. The cost of replacing defective fittings with sound ones is so small in proportion to the damage that may be done by a leak, such as vitiating the air or suffocating some person, or causing an explosion or fire, that the gas-fitter is not justified in risking anything on the durability and permanency of a cement patch. Such patches are especially unsafe if they are in the vicinity of steam or hot-water pipes or hot-air flues, or are near a hot chimney. The heat will soften the wax, and the gas pressure will slowly force it out of the hole.

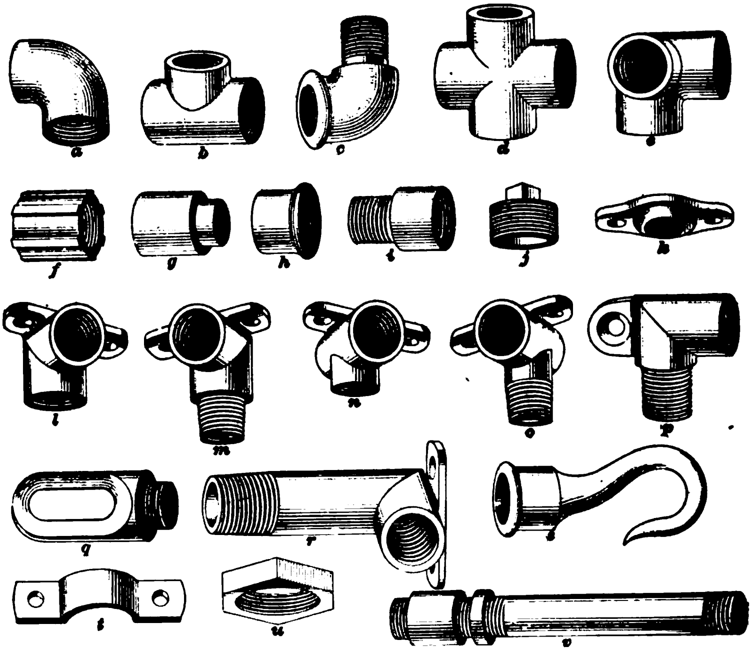


FIG. 7

22. A number of fittings especially designed for gas piping is shown in Fig. 7. They are made of malleable iron, and are known in the trade by the following names:

(*a*) Quarter elbow; (*b*) tee; (*c*) street elbow; (*d*) cross; (*e*) elbow with side outlet; (*f*) right and left coupling; (*g*) reducing coupling; (*h*) cap; (*i*) male and female extension piece; (*j*) plug; (*k*) waste nut; (*l*) drop elbow, female thread; (*m*) drop elbow, with male thread; (*n*) drop tee, with female thread; (*o*) drop tee, with male thread; (*p*) drop elbow, with male thread, left flange; (*q*) male chandelier loop; (*r*) drop elbow with long outlet piece; (*s*) chandelier hook, female; (*t*) pipe strap, tinned; (*u*) locknut; (*v*) long screw. The flanged fittings can be had either right or left, and also with male or female threads.

GAS DISTRIBUTION

FLOW OF GAS THROUGH PIPES

LAWS GOVERNING FLOW OF GAS

23. The flow of gas is governed by the same laws that govern the flow of other fluids. The rate of flow depends on: (1) the area of the pipe; (2) the length of the pipe; (3) the pressure of the gas; (4) the density of the gas; (5) the number and kind of fittings in the length of the pipe.

The volume delivered in a given time by a pipe of given area, the pressure and density of the gas remaining the same, will be inversely as the square root of the length of the pipe.

If the length, area, and density remain the same, the volume delivered will be directly as the square root of the pressure.

The pressure, length, and area remaining the same, the volume delivered will be inversely as the square root of the density.

24. If the rate of flow through any certain length of pipe is known, the volume that will be delivered by a longer or shorter pipe of the same diameter, in the same time (the pressure and density of gas remaining the same), may be found by the following rule:

Rule.—*Multiply the volume delivered by the pipe of given length by the square root of that length, and divide the product by the square root of the proposed length. The quotient will be the delivery at the proposed length.*

Example.—A certain pipe 50 feet long delivers 100 cubic feet of gas per hour; how much will it deliver if it be made 150 feet long?

Solution.—Applying the rule, we have

$$\text{delivery} = \frac{100 \times \sqrt{50}}{\sqrt{150}} = 57.71 \text{ cu. ft.} \quad \text{Ans.}$$

25. The volume that will be delivered under different pressures may be computed by the following rule:

Rule.—*Multiply the volume delivered at the given pressure by the square root of the proposed pressure, and divide the product by the square root of the given pressure. The quotient will be the delivery at the proposed pressure.*

The pressure to be considered in each case is the excess of the pressure of the gas when it enters the pipe, above the pressure existing in the chamber into which it discharges; or, in other words, it is the difference in pressures at the inlet and discharge end of the pipe.

Example.—A certain pipe discharges 100 cubic feet of gas per hour from a reservoir having an internal pressure of 1.6 inches of water, into the atmosphere; what volume will be discharged per hour if the pressure be increased to 5 inches of water?

Solution.—Applying the rule, we have

$$\text{delivery} = \frac{100 \times \sqrt{5}}{\sqrt{1.6}} = 176.7 \text{ cu. ft.} \quad \text{Ans.}$$

26. The pressure that must be put on a main to discharge a given volume, when the delivery under another pressure is known, may be computed by the following rule:

Rule.—*Square the desired volume and multiply it by the given pressure. Divide this product by the square of the known volume. The quotient will be the desired pressure.*

Example.—A certain pipe delivers 80 cubic feet of gas per hour, from a main having an internal pressure of 2.4 inches of water; what pressure must be put on the main to cause the pipe to deliver 150 cubic feet per hour?

Solution.—Applying the rule, we have

$$\text{pressure} = \frac{150^2 \times 2.4}{80^2} = 8.44 \text{ in.} \quad \text{Ans.}$$

27. The effect of variations in the density of the gas on its flow may be computed by the rule in Art. **24,** by merely substituting the word *density* for the word *length.*

The foregoing rules apply only to the *theoretical flow* of gas under perfect conditions. In practice, perfect conditions are never attained; consequently, the actual flow of gas in pipes is less in volume than that computed by the rules given. The deficiency varies according to the amount of friction and other resistances within the pipe.

28. The actual volume of gas discharged from a pipe may be calculated quite closely by the following empirical rule due to Mr. King:

Rule.—*Multiply the diameter of the pipe in inches four times by itself, and the final product by the pressure in inches of water. Divide this product by the product of the specific gravity of the gas (air being taken as 1) and the length of the pipe in yards. Extract the square root of the quotient and multiply the square root by 1,350. The product will be the number of cubic feet of gas discharged per hour.*

Example.—How much gas per hour can be discharged by a pipe 1,760 yards long and 10 inches diameter, the pressure being 3 inches and the gas having a specific gravity of .4?

Solution.—Applying the rule, we have

$$\text{delivery} = \sqrt{\frac{10 \times 10 \times 10 \times 10 \times 10 \times 3}{.4 \times 1{,}760}} \times 1{,}350 = 27{,}864 \text{ cu. ft.} \quad \text{Ans.}$$

GAS PRESSURE AND ITS MEASUREMENT

29. Influence of Height on Pressure.—If the specific gravity of a gas is less than that of air at the same temperature, the pressure will always be greater at the top of the pipe or chamber that contains the gas. If the gas is heavier than air, the greater pressure will be at the bottom of the chamber that contains it.

The upward pressure of gas having a less density than air is caused by the deficiency in its weight and its consequent inability to balance the pressure of the atmosphere.

For illustration, let us consider a column of gas 1 foot square and 100 feet high, having a density of .5, or one-half that of air, its temperature being the same as that of the atmosphere, say 60°. Now, air at 60° weighs .0764 pound per cubic foot, and a column containing 100 cubic feet will weigh .0764 × 100 = 7.64 pounds. The gas having a density of .5 will weigh only half as much, or 3.82 pounds, and is, therefore, unable to balance an equal volume of air. Consequently, it is pressed upwards with a force of 7.64 − 3.82 = 3.82 pounds against the top of the chamber that contains it. Whatever the actual pressure of the gas may be at the bottom of the column, it will, in this case, be increased at the top to the extent of 3.82 pounds per square foot.

30. The increase of pressure in each foot of rise in pipes with gas of various densities, is shown in the following table:

TABLE III

INCREASE IN GAS PRESSURE PER FOOT OF RISE

Density of gas...	1	.9	.8	.7	.6	.5	.4	.3
Increase in pressure (inches of water).........	0	.00147	.00293	.0044	.0058	.0073	.0088	.0102

Example.—The pressure in the basement, at the meter, is 1.2 inches of water; what will be the pressure at the sixth story, 70 feet above, the density of the gas being .4?

Solution.—By Table III, the increase per foot of rise is .0088 in.; hence, for 70 ft. it is .0088 × 70 = .616 in. of water. Then, pressure at sixth story is 1.2 + .616 = 1.816 in. Ans.

31. Measurement of Gas Pressure.—Since the pressures dealt with in gas supply and distribution are quite small, it is the custom to use a unit of measurement of the pressure smaller than the pound per square inch used for steam work. The universally adopted unit is the pressure per square inch exerted at its base by a column of water 1 inch high, which is .0361 pound. For the sake of brevity and convenience, the pressure is not reduced to pounds, but is expressed by simply stating the height of the water column in inches that the pressure will balance. Thus, if there be a pressure in a gas main sufficient to balance a column of water 4½ inches high, the pressure is said to equal, or to be, 4½ inches of water.

The pressure of gas is measured by the same instruments used for air and other fluids. The construction of the instruments, however, is varied somewhat for convenience in handling.

32. The most common form of gas-pressure gauge is shown in Fig. 8. It is known by different names, being respectively called a **water gauge, siphon gauge,** or **U gauge.** The tube *a* is made of metal and is provided with a socket *d* that will screw on any ordinary gas fixture in the place of a burner. The tubes *b* and *c* are made of glass and are filled with water up to the zero of the scale. The scale is graduated in inches and convenient fractions of an inch. The tube *c* is open to the air at the top. When pressure is admitted to the tube *a*, the water will sink in the tube *b* and will rise in *c*. The difference in the height of the water in the two tubes, measured in inches, is the measure of the pressure exerted in *inches of water*. The depression below zero in *b* should be added to the rise above zero in *c*. The fall in one tube will not exactly equal the rise in the other, unless the tubes are of exactly equal bore.

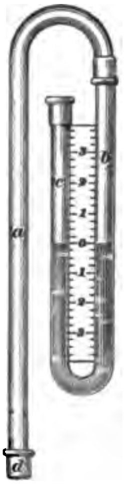


FIG. 8

Water gauges are sometimes made with scales that are graduated to one-half of actual sizes, so that only the rise in one tube need be noted. An instrument that is graduated in that way must be held exactly plumb, and the water must stand exactly at zero at the start; otherwise, it will be found that the rise and fall will not be equal, and must be averaged to get the true pressure.

33. The **Arch,** or **King, gauge,** shown in Fig. 9, consists of a cylinder *a* that runs down through the top of the tank *b* and dips its open bottom into the water with which the tank is partly filled, as shown by the dotted lines. The tank is also open at the top and contains a float, shown by dotted lines, which rests on the water inside the cylinder. This float is connected by the cord *c*, which runs over a wheel, to the weight *d*. When gas under pressure is admitted through *e* to the space above the water in the tank *b* the pressure forces the water in the tank down and the water level in the cylinder *a* is correspondingly raised. The float is raised along with the water level in the cylinder. This slacks the cord *c*, which allows the weight *d* to pull the wheel toward it. The pointer, which is on the same axis as the wheel, turns toward the right at the same time and indicates in inches of water the amount of pressure applied. The petcocks *f*, *f* are used to drain off water from the tank until the pointer is exactly at the zero mark, when the pressure in the tank is equal to that of the atmosphere.

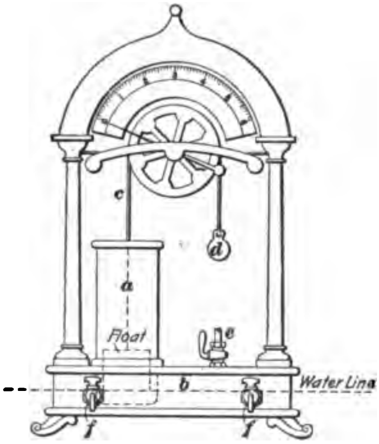


FIG. 9

The amount of movement of the pointer depends on the size of the wheel. The proportion of the apparatus may therefore be so arranged as to give any degree of sensitiveness required, and variations of pressure that could not be observed on the water gauge shown in Fig. 8 may be satisfactorily noted.

34. It is readily seen that if comparatively heavy pressures are to be measured, the water gauge will become so large as to prove inconvenient as a portable instrument. By substituting a heavier liquid for the water, the bulk will naturally be greatly reduced. The liquid generally used is mercury, which is 13.6 times heavier than water, and the gauge is then spoken of as a **mercurial gauge.**

Mercurial gauges for gas-fitters' use are commonly made as shown in Fig. 10, and are known as **cup gauges.** They are always graduated to give a reading in *inches of water*, and *not* in inches of mercury.

In Fig. 10 the mercury is contained in an iron cup *h*, and the air or gas under pressure enters through the tube *i*. The glass tube *k* is packed or cemented air-tight at *l*, and is protected by a tubular brass casing *m*. When the mercury rises in the glass tube, it sinks in the cup, but to a much smaller extent. The graduations on the brass casing indicate the difference of level that exists between the mercury in the tube when standing at that height, and the actual surface of the mercury in the cup.

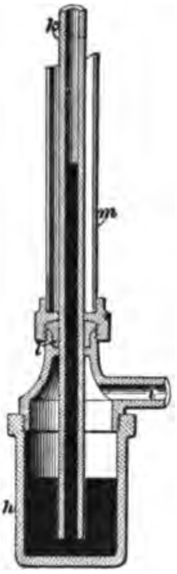


FIG. 10

To indicate correctly, this gauge must contain exactly a certain quantity of mercury, no more or less. It can be tested, or *calibrated*, at any time by comparing it with the gauge shown in Fig. 8, adding or taking out mercury from the cup until they agree. If they agree at some points and not at others, then the scale is defective and should be regraduated.

When in use, the glass tube must always be open to the air at the top.

35. Pressures that have been measured in inches of water or mercury may be changed into pounds per square inch or square foot by multiplying the reading by the following figures: 1 inch of water at 62° = 5.2 pounds per square foot; 1 inch of water at 62° = .0361 pound per square inch; 1 inch of mercury at 62° = .4917 pound per square inch.

Pressures per square inch or square foot may be converted into inches or feet of water, or inches of mercury, by multiplying the pressures by the following figures: 1 pound per square foot = .1923 inch of water at 62°; 1 pound per square inch = 27.7 inches of water at 62°; 1 pound per square inch = 2.042 inches of mercury at 62°; 1 inch of mercury column = 13.6 inches of water column.

MEASURING VELOCITY OF FLOW OF GAS

36. The velocity of gas flowing through a pipe may be measured by means of **Pitot's tube,** which is shown in Fig. 11. It consists of two tubes *a* and *b*, which are secured in a suitable plug *c*. The lower end of *a* is straight, but the end of *b* is curved to face the current, as shown. The upper ends of the tubes are connected to a water gauge *d*. The pressure that affects the gauge is due to the momentum of the gas that strikes the open end of the tube *b*. The velocity that corresponds to any certain indication of the water gauge may be found by referring to the tables that are furnished by the maker of the instrument.

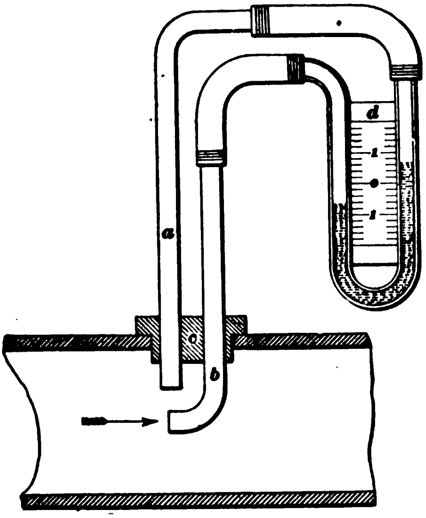


FIG. 11

The volume of gas passing through a pipe in a given time is computed by multiplying the velocity, as found by Pitot's tube, by the area of the pipe.

37. The actual quantity of the gas, or the **standard volume,** is computed by correcting the volume for temperature and pressure, reducing it to a volume at standard temperature of 32° and standard pressure of 1 inch of water. The correction for temperature and pressure is made by the following rule:

Rule.—*Multiply the volume by 1.206 and by the sum of the pressure in inches of water and 407. Divide the product by the sum of the temperature (in degrees Fahrenheit) and 460. The quotient will be the standard volume.*

EXAMPLE.—A certain gas pipe passes 2,252 cubic feet of gas per hour at a temperature of 94 degrees under a pressure of 8 inches of water. What is the standard volume?

SOLUTION.—Applying the rule just given, we have

$$\text{standard volume} = \frac{2{,}252 \times 1.206 \times (8 + 407)}{94 + 460} = 2{,}034.5 \text{ cu. ft.} \quad \text{Ans.}$$

In dealing with gas it is necessary to keep in mind a clear distinction between the *apparent volume* of the gas and the *actual quantity*. The former is the volume as measured at the actual temperature and pressure, while the latter is the volume of the same gas at standard temperature and pressure.

MEASURING VOLUME OF GAS

38. Introduction.—For ordinary purposes, the volume of gas passing through a pipe is measured by an apparatus called a **gas meter.** A gas meter measures the *volume* only. It does not give any indication as to the pressure under which gas is being metered, but as most meters are adjusted at a pressure of less than 2 inches of water column, and as that pressure is usually the minimum used in the street mains, the error possible from variations in pressure is very slight. For example, if a meter registers 1,000 cubic feet of gas at the pressure for which it is adjusted, say 2 inches of water, it will actually pass 1,004.9 cubic feet at 5 inches pressure, and yet register but 1,000 cubic feet. It is thus seen that the error is less than one-half of 1 per cent. for an increase in pressure of 3 inches, and in favor of the customer, and not of the gas company, as is commonly assumed.

The maximum pressure at any meter is seldom more than 5 inches; the average maximum pressure of the total number of meters in use on any system of mains is probably not more than 3 inches. Wherever gas is piped under very high pressure, as in the case of natural gas, or where illuminating gas is pumped from one district to another, a governor or reducing valve is always placed on the service, so that the pressure is reduced before the gas reaches the meter.

39. Construction of Gas Meters.—Meters for measuring the volume of gas have been constructed in many ways. The kinds that are most in use at the present time are shown in Figs. 12, 13, and 14.

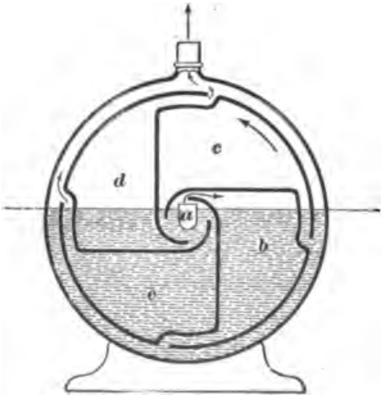


Fig. 12

The **wet meter** is shown in Fig. 12. The gas enters through a pipe *a*, which opens just above the surface of the water. The measuring is done by means of a revolving cylinder that is divided by partitions into four chambers *b*, *c*, *d*, and *e*. The inner ends of the partitions are curved so that they dip under the water and prevent the incoming gas from entering into any other chamber than the one that is rising out of the water. In the figure, gas is beginning to fill the chamber *b*, and it is discharging freely from the chamber *d* into the outer casing to which the discharge pipe is attached. The outlet of the chamber *c* is still under water, and no gas can escape from it until the cylinder turns over a little farther. The filling and emptying of the chambers continue as long as any gas is passing through the meter.

The capacity of each chamber depends on the level of the water within it; consequently, the water must be kept exactly at a proper level at all times to enable the meter to measure accurately. The axis of the cylinder must be exactly horizontal; otherwise, the capacity of the chambers will be increased and the meter will indicate less than the true volume passing through. Also, the water will evaporate and pass off as vapor along with the gas, and, unless replenished, the meter will become more and more inaccurate, until finally the gas will pass through without registering at all. Many dishonest persons have taken advantage of the fact that by tipping the meter so that one end of the cylinder is considerably higher than the other, the water may be made to uncover the inlet and outlet openings of a chamber at the same time, thus permitting the gas to pass through without turning the cylinder or registering.

The best forms of wet meters are provided with a float attachment that automatically closes the gas inlet when the water-line is too high or too low, thus obtaining a reasonably uniform measuring capacity in the meter, and preventing a passage of gas without a corresponding movement of the drum.

The wet meter is sufficiently accurate if kept in good order, but owing to the defects mentioned, it is now but little used for measuring the amount of gas supplied to consumers. It is still employed at gasworks, in preference to all others, to measure the total amount of gas produced. For this purpose it is made very large and is provided with glass gauges by which the level of the water may be observed and accurately controlled. It is then called a **station meter.**

40. An ordinary design of **dry meter** is shown in Fig. 13. The measuring is done by means of two bellows *a* and *b*, which are alternately inflated and emptied. The meter case is divided into three chambers, the upper one containing the valves *c* and *d* and the registering mechanism. The body of the case is divided by a partition *e* into two equal chambers, each of which contains one of the bellows. Each bellows consists of a large circular plate *f* attached to and supported by the vertical rock shaft *g*, and a flexible ring or diaphragm *h*, having one edge secured to the plate *f* and the other to the middle partition *e*. The rock shafts *g*, *g* are connected at the top by arms and links to a central crank *k*. The throw or stroke of the plates *f* is thus limited to an exact distance, and the relative movements of the two bellows are so timed that the movement of gas through them is steady and nearly uniform. The interior and exterior spaces of the two bellows constitute four measuring chambers, and the gas is admitted to and released from them in rotation, by the movement of the slide valves *c* and *d*. These valves are moved by means of links connected to the crank on the lower end of the central shaft *l*. The amount of gas passed through by each bellows at one revolution of the shaft nearly equals the area of the circle filled by the leather ring *h* multiplied by the actual distance through which the plate *f* is moved, or twice its stroke.

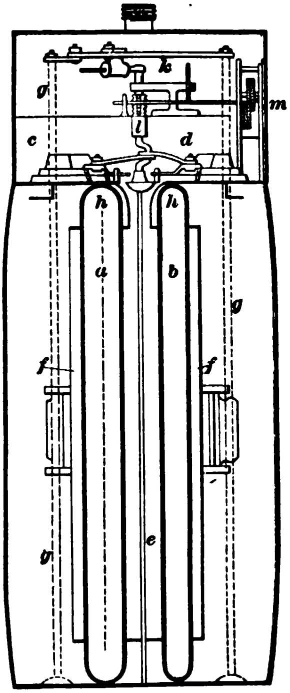
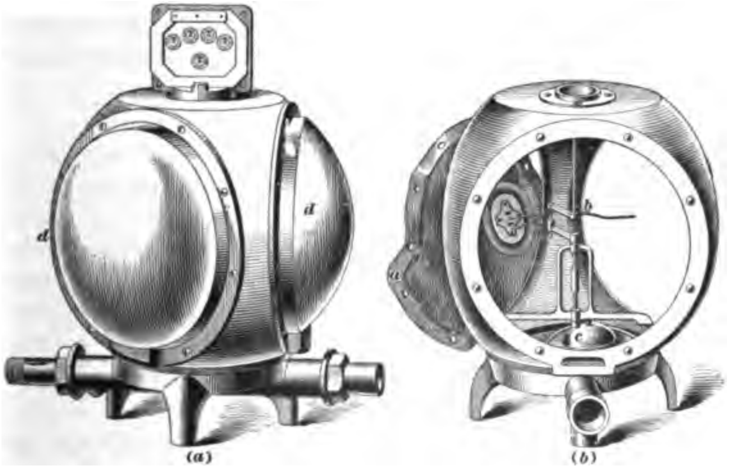


FIG. 13

The capacity of the meter is regulated by adjusting the radius of the crank *k*, and thus changing the length of the stroke of the bellows. The rotations of the shaft are recorded by the registering mechanism at *m*, and the volume passed through is indicated in cubic feet.

The rings or diaphragms *h* are usually made of fine leather. After long service these rings are liable to become hard and stiff, and to crack. To keep them in good serviceable condition, they must be oiled at intervals. When the meter is used for gas that has not been properly purified, the leather rings are liable to become coated with tarry matter and thus be spoiled.

41. Dry meters are also made with three diaphragms, and the diaphragms are sometimes made square. An external view of a dry meter designed especially for natural gas and high pressures is shown in Fig. 14 (*a*), and an inside view of the working part in Fig. 14 (*b*), in which view two of the diaphragms and the cover-plates have been removed.



(*a*) (*b*)

FIG. 14

Three diaphragms, as *a*, are employed, each one being connected by a link to the central crank *b*. The diaphragms are single-acting, that is, they displace gas only when they move outwards into the chambers enclosed by the covers *d*. The central or main chamber is filled with gas at full pressure at all times. The gas is admitted and released from the measuring chambers behind the diaphragms by means of a hollow circular slide valve *c* that is attached to the crank on the lower end of the central shaft. When gas is admitted to a measuring chamber, the diaphragm is balanced, having an equal pressure on each side, and it moves inwards in obedience to the crank, without resistance, thus filling the chamber behind it. But when the valve cuts off the fresh gas and opens a duct into the delivery pipe, the pressure in the central chamber exceeds that in the delivery pipe, and the diaphragm is driven outwards, expelling the gas from the measuring chamber. Thus the measuring chambers are filled and emptied in regular rotation. The shape of the meter being spherical, it can endure high pressures without distortion or any impairment of its accuracy.

42. All gas meters require a certain small amount of power to operate them; consequently, the pressure of the gas will be slightly reduced in passing through the meter. In the ordinary size used in dwellings, the reduction of pressure usually amounts to about .2 inch of water, sometimes more. When gas is supplied at very low pressure, it becomes difficult to use a meter, because the resistance that it offers diminishes the pressure at the burners to such an extent that the gas will not burn well.

Thus, if gas is furnished at a pressure of .5 inch and the resistance of the meter is .2, then the gas passing to the burners will have a pressure of only .3 inch, and will burn in such a languid way that it will be very unsatisfactory.

43. Size of Gas Meter.—The numbers usually affixed to gas meters indicate the number of gas burners consuming 5 cubic feet each per hour, which the meter will supply with ease and certainty. In practice, the number of burners may be increased to double the number on the meter.

Gas meters should not be exposed to a lower temperature than 40°, nor a higher temperature than 100°, since the oiled leather in the diaphragms will be injuriously affected thereby.

Some knowledge of the internal condition of a meter can be ascertained by noting the difference in pressure in the supply and delivery pipes. A water gauge should be attached to each pipe as close to the meter as practicable. If the gauges show a difference greater than .2 inch in pressure, the meter should be removed and examined. The accumulation of water in the meter may cause the trouble, in which case it must be emptied. Or, the meter may be out of order, in which case it must be repaired.

44. Reading Gas Meters.—Fig. 15 is a diagram of a **meter dial** of the ordinary type. When the pointers all point to the zero mark on their respective dials, the meter is said to be at zero. If the meter is at zero and a certain volume of gas is allowed to pass through it, the number of cubic feet of gas passing through the meter will be indicated on the dials. If the meter is not at zero, however, the number of cubic feet of gas that has actually passed through during the time specified is equal to the difference between

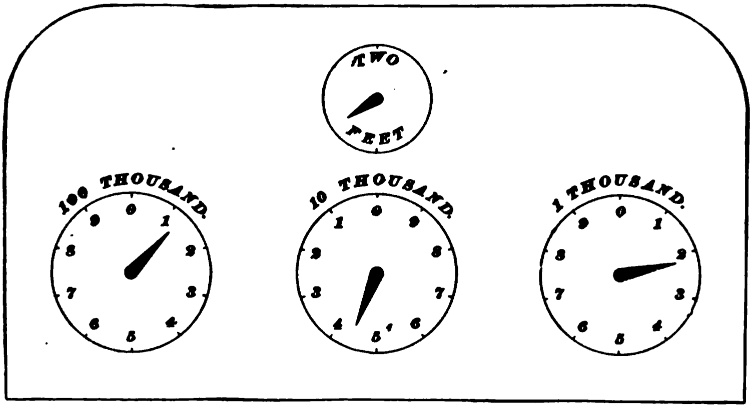


FIG. 15

the number indicated on the dials before the gas was allowed to flow through the meter and that indicated when the gas has flowed through.

The top dial is marked *two feet*, which means that when 2 cubic feet of gas have passed through the meter the pointer of this dial will have made one revolution.

When 1,000 cubic feet of gas have passed through the meter, the pointer of the dial to the right, which is marked *1 thousand*, will have made one complete revolution, and the pointer of the middle, or *10 thousand*, dial will have moved from 0 to 1. When the pointer to the right has made another revolution, the pointer of the middle dial will have moved from 1 to 2, which means that two complete revolutions of the pointer to the right have been made. When the middle pointer has made one complete revolution, the pointer to the left will have moved from 0 to 1 on the *100 thousand* dial, which means that $\frac{1}{10}$ of 100,000, or 10,000 cubic feet, have passed through the meter.

To read a meter dial of this description, first write down the figure that the pointer has just passed on each dial; then annex two ciphers to the right; the number so obtained will be the amount of gas in cubic feet that the meter has measured. The dials should be read from left to right.

Thus, the pointers on the diagram indicate that 14,200 cubic feet of gas have passed through the meter. When the pointer to the left has made one complete revolution, the process of indicating is repeated. The pointers all move from the smaller to the larger figures, just like the hands of a clock.

Gas meters are not read in practice to a smaller amount than 100 cubic feet. By watching the top dial it can be seen, at a very small expenditure of gas, whether the meter is working, by opening some outlet on the house side of the meter.

45. Testing Gas Meters.—Meters are tested by means of a **meter prover.** This is principally composed of a metal cylinder or gas holder *a*, Fig. 16, usually capable of holding either 5 or 10 cubic feet of gas. The holder is open at the bottom, and is placed inside a slightly larger cylinder or tank *b*, which is open at the top and nearly filled with water. There is a pipe in the center of the water tank, the upper end of which pipe terminates above the water level, the lower end connecting to the pipe *c*. This pipe gives an inlet and outlet to the space between the top of the water and the under side of the top of the gas holder. The holder is free to rise up out of the water, and its weight is partly counterbalanced by a cord or chain that runs over a wheel set above the tank and that has a weight or counterbalance *d* on the other end. The counterbalance is usually such that a pressure of more than 1½ inches of water column under the tank

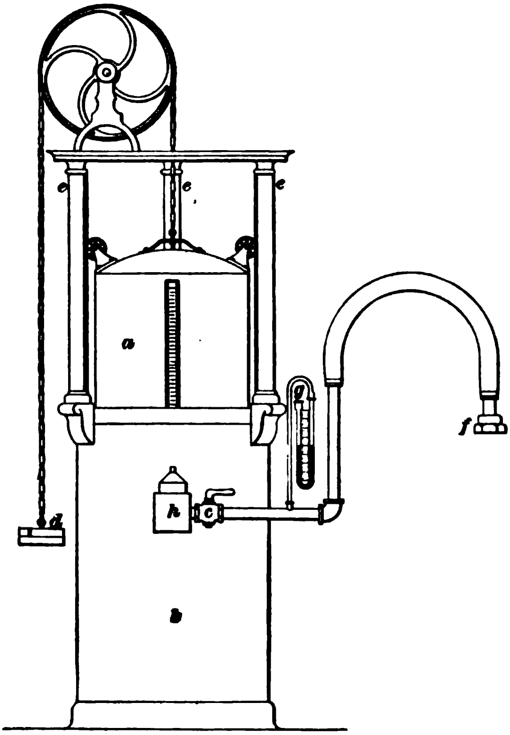


FIG. 16

will raise it. The tank is guided while it is raised by guide wheels that are set at three points on its circumference and run against the guide posts *e*, *e*. A scale is attached to the outside of the holder and shows in subdivisions of a cubic foot how much air or gas is required to fill the space above the water at any height the tank might be in the water. As the results are the same with either air or gas, air is generally used in the prover for the sake of convenience. The pipe *c* that comes from the inside of the prover is provided with a valve for the admission of air and with another valve leading to a connection, usually on the end of a rubber hose, for the attachment of meters. A **U** gauge is always provided near the outlet of this valve, as shown at *g*.

46. The prover is operated as follows: A meter is connected to the coupling end *f* of the rubber hose, and the cock *c* is closed. The air valve at *h* is then opened and the tank is raised a little by pulling down on the counterbalance. Air thereupon enters the inside of the tank through the air valve, which is closed before the counterbalance is released. The outlet of the meter is closed either by the hand or by a suitable cap, and the cock admitting air to the meter is opened. The gauge will at once show a pressure of 1½ inches. The cock *c* is then closed and the pressure gauge observed. If the gauge remains at 1½-inch pressure, the test may be proceeded with, but if the pressure falls, there is a leak somewhere in the connections; this leak must be found and stopped and the above leak test repeated before anything else is done.

All connections being gas-tight, the cap is removed from the meter outlet, the cock *c* is opened, and air is allowed to pass through the meter until the 2-foot hand just points toward one of the side marks on the 2-foot dial. A meter test should never be started from either the bottom or top mark. When the hand reaches the side mark, the cock *c* is closed. The air valve is then opened and the prover tank is raised until the zero mark on the scale is 2 or 3 inches above a pointer that is set on the water tank *b* just above the water-line. The air valve is then closed and the prover tank released. The prover tank will come to rest, supported by the air that has been drawn inside it, and the zero mark will be a little above the pointer. The air valve is then opened a little and air is allowed to escape until the zero mark is just level with the pointer. The air valve is now closed and the meter cock *c* is opened. The air will pass out through the meter and the small hand on the meter dial will at once begin to move. The small hand should be carefully watched, and when it has made one complete revolution and returned to the side mark from which it started, the meter cock *c* should be quickly closed.

The pointer will be found to point exactly at the 2-foot mark on the prover tank scale if the meter is exactly right. If the pointer points at a point on the scale that is $\frac{1}{100}$ of 2 feet above the 2-foot mark, 1 per cent. more air has gone through the meter than the meter has registered, and the meter is accordingly 1 per cent. slow. If the pointer points at a corresponding position below the 2-foot mark, the meter has registered 2 feet when only $\frac{99}{100}$ of 2 feet of air has left the prover, and the meter is 1 per cent. fast. The subdivisions on the prover scale are usually arranged so that the direct reading shows the percentage fast or slow, each subdivision being equal to 1 per cent.; hence, no calculating is necessary. On large meters the small hand may register 5 or even 10 cubic feet at one revolution, and a proper subdivision for directly reading a 5-foot and 10-foot test will usually be found on the prover scale.

47. The test described in the preceding article is called the **open test,** because the meter has been open, or rather, blowing with a full opening, to the atmosphere. After the open test has been made, the same process should be repeated with a cap, in which a small hole has been drilled, placed on the outlet of the meter. The hole in this cap should be of such a size that the number of feet of gas passed per hour will be equal to six times the number of burners the meter is rated for. Thus, a 3-light meter cap has a hole large enough to pass about 18 cubic feet per hour. This test is for the purpose of placing the meter more nearly under the conditions of average use; it is called the **slow test.** The slow and open tests should agree within 2 per cent., and if they do not, there is something wrong with the meter and it should be opened and repaired. The slow test should be taken as the correct test of the meter. Suitable caps are always provided by the manufacturers of meter provers. In proving meters, it is necessary to have the temperature of the air in the room and of the water in the prover tank as nearly the same as possible, and two thermometers should be provided for observing this.

As each difference of 5° will make a difference of about 1 per cent. between the registration of the meter and that of the prover, the necessity of an even temperature may be readily seen. The water in the prover tank may be readily brought to the temperature of the air in the room by adding cold water if it is too hot and hot water if it is too cold. Meters, for the reason above stated, should be allowed to remain in the proving room for some time before being tested, and if they have been brought in from outdoors on very cold or very hot days, several hours should be allowed to elapse before proving them. If the meter, the air in the room, and the water in the prover are all at the same temperature, it makes no practical difference what that temperature may be. In many shops it is considered better to allow the 2-foot hand on the meter to make two revolutions instead of one during a test. In this case each division on the prover scale that would be 1 per cent. in a single revolution will be ½ per cent.

48. When very large meters are to be proved, the test dial frequently requires more air for one complete revolution than the capacity of the prover will allow. In this case the prover must be filled twice or more. Supposing a meter, the test dial of which registers 20 cubic feet, is to be tested on a 10-foot prover. The prover is set at zero and the test hand at one of the side marks, and exactly 10 cubic feet by the prover scale is allowed to pass to the meter. No attention being given to the position of the dial hand when it stops, the prover is refilled with air and brought to zero again and once more allowed to descend. This time the hand on the meter is watched, and when it gets around to the point from which it started, the meter cock is again shut and the reading on the scale taken. In this case it will be readily seen that each difference of $\frac{2}{10}$ foot above or below the 10-foot mark amounts to 1 per cent. slow or fast, as the case may be.

49. Accuracy of Gas Meters.—Meters that are within 2 per cent. of being correct are regarded as right, whether fast or slow, this being the range generally allowed by law in places where laws governing the registration of meters exist. Notwithstanding the prejudice of the public to the contrary, the tendency of all meters is to run slow rather than fast. Indeed, every dry meter, if left in use long enough, will run slow, as sooner or later the leather diaphragms begin to rot and small holes appear that allow gas to pass without registering, and these holes grow larger and larger until the meter ceases to register any of the gas that passes through it. For this reason it is good practice for gas companies to make a routine test of some of the meters in use in any district each year, so that every meter will be tested once in 3 or 4 years.

The life of the diaphragms may be very much prolonged if the meters are opened up and the diaphragms oiled with neatsfoot oil.

GAS SUPPLY AND DISTRIBUTION

(PART 2)

GAS DISTRIBUTION

REGULATING FLOW OF GAS

INTRODUCTION

1. The pressure in gas mains and services is mainly artificial, being created by the weight of the holders in which the gas is stored at the works. This pressure is regulated by a governor at the works to a day pressure of about 2 inches, as the ranges and other fuel appliances in use work best at about this pressure. At night, when there is a very heavy consumption of gas, it is frequently necessary to increase the pressure at the works to 4 or 5 inches in order to deliver gas with sufficient pressure to the consumers at the far ends of the mains. On this account the consumers near the works have more pressure than is necessary, which is very undesirable. Here it may be mentioned that any increase in gas pressure means an increase in the leakage of gas mains, and for this reason, contrary to the usual belief, gas companies rarely carry more than just enough pressure to supply the more distant points of their main system properly.

A burner that is designed to consume, say, 5 cubic feet of gas per hour, will work most efficiently when it is supplied with just that quantity—neither more nor less. If only 4 cubic feet are supplied, the flame will be dull and smoky,

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and the amount of light will be considerably less than that normally produced by a 4-foot burner using the same gas. If 6 cubic feet be forced through the burner, the flame will flare and jump, and the light given off will be less than that produced by the same amount of gas going through a 6-foot burner.

If the volume of gas passed through a burner considerably exceeds the amount it was designed to burn, some of the excess will pass through without being burned, and will vitiate the air of the room in which it is used.

2. The pressure that should be given to the gas at the burners, in order to secure the best results, varies greatly in different forms of apparatus. The following are the pressures generally used: Argand burners, .2 inch of water; common batswing burners, .5 inch of water; Welsbach incandescent burners, 1 inch or more; Wenham and Lebrun lamps, .5 to 1 inch or more; atmospheric burners, 1 inch or more.

For the sake of economy it is important that both the volume and pressure at the burners should be closely regulated. The amount of gas wasted by overpressure is much greater than generally known. A good new lava tip burner consuming 5 cubic feet per hour at .5 inch pressure will consume about .5 cubic foot more for each increase of .1 inch in the pressure. Thus, an overpressure of .1 inch will increase the gas bill about 10 per cent.

The variation in the gas pressure in the mains, even in the best regulated systems, is usually much greater than .1 inch, frequently being 1 inch and more.

3. The pressure of gas is regulated by a device known as a **gas-pressure regulator** and also as a **gas governor.** The objects sought in the use of pressure regulators or governors are (1) economy in the consumption of gas, and (2) steadiness of the lights and the most effective operation of the burners.

There are two systems of gas regulation now in use, called, respectively, the *pressure regulation* and the *volumetric regulation* systems. In the first system, a governor is attached to the service pipe at the meter, and the house distributing pipes contain gas at a constant pressure; in the second system, each burner is supplied with a governor, and the pressure in the house pipes is not controlled, being about the same as in the mains.

PRESSURE REGULATION SYSTEM

4. For the successful working of the **pressure regulation** system it is necessary that the house pipes be of such size as to permit an adequate supply to all burners without loss in pressure between the burner and the governor. Where the piping system is very extended, or the pipes are small, the governor should be adjusted to the minimum pressure of the gas in the street mains, and either volumetric burners or suitable *check-burners* applied. A **check-burner** is a gas burner supplied with a suitable device for regulating the size of opening through which the gas flows to the tip. Ordinary burners can be converted into check-burners by stuffing cotton into the pillar, and where gas that has been properly scrubbed and purified is used, this form of check is fairly satisfactory, but the cotton must be put in with good judgment so that the proper sized flame for the tip is developed. It must be noted that the difference in specific gravity of coal gas and water gas makes an appreciable difference in the amount of gas that will flow through a given burner under the same pressure. As coal gas is much the lighter, it will require a smaller check-opening than water gas. Where Welsbach lights and fuel appliances are to be used on the same system of piping as open burners, the governor on the service pipe should be adjusted to the minimum street pressure, usually about 2 inches, and check-burners should then be applied to the open lights. Both Welsbach lights and fuel appliances give best results under high pressure. Thus, a Welsbach lamp adjusted to burn 3½ feet per hour at a pressure of 2 inches will give considerably more light than the same lamp adjusted to burn the same amount of gas at a pressure of 1 inch. In very high buildings the pressure on the top floors will be much higher than on the lower floors. In this case it is necessary to install a separate governor for each floor.

5. The ordinary practice is to put the governor on the house side of the meter. This is the proper place for the governor in most cases, as the governor will respond more quickly with an increase or decrease of volume when lights are turned on or off, and it also has a tendency to cushion any slight jumping motion to the gas that the meter may give if it works a little stiff. There is a use, however, for a pressure regulator on the service pipe that may be of importance in some situations. Thus, where services are tapped into mains used for pumping gas from one point to another and where accordingly very high pressures are used, a governor of the diaphragm type should be placed in the service pipe in order to reduce the pressure at the meter to a reasonable amount.

VOLUMETRIC REGULATION SYSTEM

6. The system of **volumetric regulation** is free from all the difficulties experienced with the pressure regulation system. No governors are required on the house pipe or service pipe; the pressure in the house pipes is about the same as in the street main, and it may fluctuate to any extent, provided that it never falls too low to supply enough gas. Under this system every burner has its own governor, and, if the regulators are properly adjusted, each burner will have the proper amount of gas at just the right pressure to enable it to produce light in the most economical manner. While the system of pressure regulation is far more economical than the use of check-burners without other regulation, yet it cannot regulate the pressure and volume with the nicety required for really successful lighting, and given by a properly adjusted volumetric regulation system. In order to make the volumetric system more efficient than the use of governors with proper check-burners, it is necessary to adjust the volume supplied to each individual tip with the utmost care, so that just the proper amount of gas is burned.

As tips frequently become more or less clogged with an accumulation of dust or carbon in a short time, the adjustment is usually far from perfect, and it will then be found in actual practice that the use of check-burners with a governor will give almost as good results. This shows the importance of proper periodic adjustment in order to realize the inherent benefit of a volumetric regulation system.

CONSTRUCTION OF GAS PRESSURE REGULATORS

7. Pressure regulators for gas are designed to receive gas at a high and variable pressure, and to deliver it at a lower but steady pressure. In principle, they belong to the general class of devices known as automatic reducing valves. A regulator suitable for large pipes or mains is shown in Fig. 1. It consists of a hollow cylinder or drum *a* that floats in water within the tank *b*. The drum is guided by means of a rod *c* at the top and rollers *d*, *d* at the bottom. The gas is brought in through the pipe *e* and is discharged at *f*. The passage of the gas is controlled by the valve *g*, which is attached by a chain to the top of the drum *a*. A very slight increase in the pressure of the gas within the drum and pipe *f* will cause the drum to lift and reduce the opening between the valve *g* and its seat, thus checking the inflow of gas. Similarly, if the pressure should fall, the drum would sink

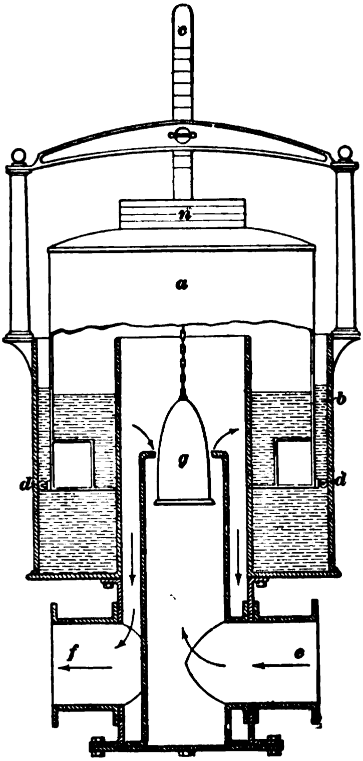

Fig. 1

and increase the opening of the valve until the pressure in the delivery pipe rose to the point for which the regulator was adjusted. The pressure in the delivery pipe may be determined by increasing or diminishing the weights at *n*.

The pressure in the delivery pipe is not exactly constant with this regulator; but, the variation is confined within such narrow limits that the purpose of regulation is accomplished with sufficient accuracy for all ordinary purposes.

Small regulators for domestic use are constructed on the same principle as the regulator just described. Water is unsuitable for small regulators because it evaporates so easily. In many instances glycerine is used in place of water, since it will not evaporate at any ordinary temperature. Mercury is also used with complete success.

8. In another type of gas pressure regulator the floating drum is replaced by a flexible diaphragm *a*, as shown in Fig. 2. This diaphragm rises and falls with the variations in pressure in the delivery pipe, and operates the valve *b* in the same manner as the floating drum in Fig. 1. This kind of regulator is called a *dry governor*, and such governors are used on the gas pipes within the house. Both types of governors illustrated are also made of sufficiently small dimensions to control single gas burners, and are frequently united with them in the same structure.

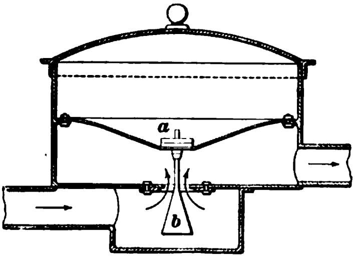

FIG. 2

CONSTRUCTION OF VOLUMETRIC REGULATORS

9. A very successful burner containing a **wet volumetric governor** is shown in Fig. 3. The gas passes upwards through the valve seat *a* into the interior of an inverted cup *b*, which floats in glycerine *d*, contained in the lower part of the shell *c*. It escapes from the floating cup through two small holes, which are made of a size that will pass the desired quantity of gas that the burner is intended to consume per hour, at a pressure of .5 inch of water. If the pressure within the cup exceeds that amount, the cup will rise and partially close the valve. It thus maintains the pressure at the tip very close to .5 inch at all times, and insures a steady rate of consumption, although the pressure in the pipes may fluctuate through 20 inches or more.

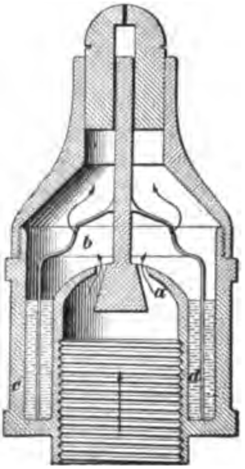

FIG. 3

10. One of the most improved forms of **dry volumetric governors** for single gas burners is shown in Fig. 4. The flow of gas to the burner tip is controlled by a tubular valve *a*, which closes against a seat *b*, and which is attached to a very light disk *d*. This disk moves up and down freely, like a piston, in the cylindrical chamber *c*, being guided also by the central post. Gas is admitted freely to the under side of the disk, and a certain quantity is permitted to pass around to the upper side through the hole *e*. The volume of gas passing through this hole may be changed by means of the regulating screw *f*. The weight of the disk and valve is made such that it will require a certain excess of pressure on its under side, say ½ inch, to lift it. When it begins to rise, there is nothing to stop its upward movement or to prevent the valve *a* from closing the outlet, except the

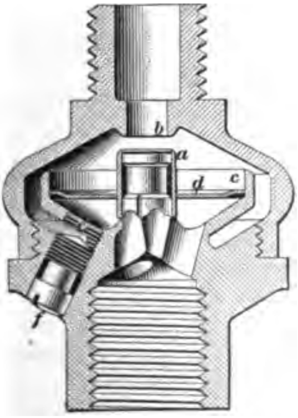

FIG. 4

circumstance that as the outlet becomes choked, the pressure above the disk increases until it approximates or equals the pressure below it. The excess of pressure on its under side is thus diminished and is no longer sufficient to hold it up; consequently, it will gradually drop and increase the outlet opening until the pressure above the disk becomes $\frac{1}{2}$ inch less than that below it. Thus, the pressure of the gas escaping past the valve to the burner will always equal the difference in pressure on the upper and lower sides of the disk, in this case about .5 inch; and the volume will depend on the size of the orifice as determined by the screw *f*. By adjusting this screw, the governor can be arranged to deliver gas in any volume within its scope.

11. It should be observed that there is a radical difference in the effect produced by the two classes of governors described. The governors shown in Figs. 1 and 2 operate only to regulate the pressure in the delivery pipes; they do not limit or control the volume of the gas passing through. They will pass enough gas to maintain the pressure, no matter whether the amount be 10 feet per hour or 1,000 feet per hour.

The governors shown in Figs. 3 and 4 not only control the pressure of the gas that is delivered to the burner, but they determine the volume, also, with great exactness. The gas is compelled in each case to pass through fixed orifices, which will, of course, pass only a certain volume per hour at the pressure for which they are adjusted. Any attempt to increase or diminish the volume passing instantly changes the internal pressure and causes the regulating valve to move.

PIPING BUILDINGS

INTRODUCTION

SIZE OF PIPES

12. The capacity of each pipe must be great enough to supply all the burners that receive gas through it, when every burner is in full operation. Allowance must also be made for all heating and cooking apparatus, not only for that which is decided on, but for all that is liable to be required.

Service pipes should never be less than ¾ inch in diameter, because of the liability to chokage, and it is advisable to make the diameter at least 1 inch if the pipe is of iron. For small cook stoves, the supply pipe should be at least ¾ inch in diameter, and larger stoves should have pipes from 1 inch to 1½ inches in diameter.

The quantity of gas burned by gas burners varies not only with their construction but also with their condition, and may be as low as 2½ cubic feet per hour and as high as 7 cubic feet, or more. Nothing short of an actual test will give the amount of gas really burned per hour. In installing a gas-lighting system, it is obviously necessary to compute the required size of the piping on the assumption that each burner consumes a certain number of cubic feet of gas per hour. Practical experience has shown that the average consumption of various gas burners is about 5 cubic feet, and hence it is customary to install piping systems in accordance with the assumption that each burner consumes 5 cubic feet of gas per hour, unless the specifications under which the work is done specify otherwise.

TABLE I

CAPACITY OF GAS PIPES

Diameter of Pipe Inches	Maximum Length Feet	Capacity Per Hour Cubic Feet		Number of Burners Acetylene Gas
		Coal Gas	Gasoline Gas	
¼	6	10		
¼	20			4
⅜	20	15	10	
⅜	40			7
½	30	30	20	
½	60			15
¾	50	100	75	
¾	100			50
1	70	175	125	
1	150			80
1¼	100	300	200	
1¼	250			150
1½	150	500	350	
2	200	1,000	700	
2½	300	1,500	1,100	
3	450	2,250	1,500	
4	600	3,750	2,500	

Having ascertained the probable maximum quantity of gas required in cubic feet per hour, the necessary nominal diameter of the pipe can be found from Table I. If the length of the proposed pipe exceeds the maximum length given in the table, then the diameter chosen should be the next size larger. If the pressure of gas exceeds 2 inches of water, the principal pipes may be reduced in diameter one size. If the pressure is less than 1 inch of water, then all the pipes must be made one size larger, and in case of very long pipes, the diameter will require to be increased still more.

When carbureted air, which usually is gasoline gas, is used, no distributing pipe should be less than ⅜ inch in diameter. For acetylene gas no distributing pipe smaller than ¼ inch should ever be used.

Some gas companies issue rules governing the installation of piping systems in buildings supplied with gas by them. Wherever this is the case, the installation should conform with the prescribed rules, copies of which can generally be had free on application at the office of the company issuing them.

The pressure of the gas is assumed in the foregoing table to be about 2 inches of water column. It should be understood that the quantities given are those that the pipes will deliver at the burners without objectionable fall of pressure.

The use of the table is shown by the following example:

EXAMPLE.—What diameter of pipe should be used to supply three ordinary coal-gas burners, the length being 60 feet?

SOLUTION.—The quantity consumed will be 3 × 5 = 15 cu. ft. per hour. The table shows that ⅜-inch pipe can be depended on to deliver that quantity of gas at a distance of 20 ft. only; therefore, it will not serve properly to carry 60 ft. The ¾-inch pipe is evidently too large; therefore, the intermediate size—½-inch in diameter—may be used.
Ans.

PIPE FITTING

13. The methods of cutting, bending, threading, and jointing gas pipes within buildings are exactly the same as those employed in installing wrought-iron and steel pipe systems for plumbing and heating purposes. It should be borne in mind, however, that the tightness of all screw joints should depend on the perfection of the screw threads, and not on any red lead or cement that may be used in closing the joints. Therefore, all threading tools should be kept sharp, and in strictly good order at all times.

In cutting threads at the pipe vise, the pipe should not project any farther than is necessary to give elbow room while working the dies, because the farther away the dies are from the vise, the greater is the torsional stress upon the pipe, and the more liable it is to be strained or split in the butt-welded joint.

It is customary to cut and thread all the pipes required for an ordinary building on the premises where they are used, and to do the work exclusively with hand tools. On large jobs, however, where the gas pipes are larger than 1 inch, a great saving in labor and time can be effected by cutting and threading the large pipes with suitable power-driven machines in the shop, cutting and threading only the smaller pipes and doing the special fitting on the premises where the gas-lighting system is being installed. If the working plans are made with reasonable accuracy, there will be no difficulty in preparing the pipes and fittings at the shop, so that they may be put into their places in the building and screwed together with entire success.

In screwing pipes together, or into fittings, the pipe should be gripped as close to the fitting as practicable so as to prevent the pipe from being split by twisting.

After pipes are cut and threaded, each piece should be carefully inspected to see whether it is free from cracks or splits, and to see whether its length conforms to the drawing.

DRAINAGE OF PIPES

14. Illuminating gas nearly always contains a small percentage of watery vapor, and this condenses on the interior of the pipe. The condensed water will flow to the lowest point in the pipe, and if no provision is made for its removal, it will accumulate to such an extent as to close the passage and stop the flow of gas. Therefore, all horizontal pipes, unless very short, must be so inclined that they will drain properly. All the branches of a riser must be inclined to drain back into it, or, if the branch be very long, it may be inclined so as to drain into a drip cup at some intermediate point. Usually the whole system of house pipes is arranged to drain back into a drip cup at the meter.

Drip cups must always be located at some point where they can be got at and emptied without difficulty. It is considered good practice to place a plugged **T** at the base of a riser at the cellar ceiling instead of a 90° elbow. Should the riser sag and make a trap at the base, or should rust fall down the riser and choke the base, it can easily be cleared after unscrewing the plug.

Gas pipes composed of lead or other soft metals should not be used in ordinary buildings. If such gas pipes are specified for special work, they must be protected against sagging by running them on a ledge or shelf. Every sag operates as a pocket to collect water, and if the depression of one of the sags equals the diameter of the pipe, the accumulation of water will eventually choke the pipe and stop the flow of gas.

INSTALLING THE PIPING

GAS-FITTERS' PLANS

15. The location of gas fixtures is generally indicated on the architect's plans by a star, thus *, and the number of burners on each fixture, together with the height of the fixture above the floor, is stated in the specifications.

To facilitate the work of running the pipes and of estimating their proper sizes, the gas-fitter should make plans of the piping on each floor. An outline tracing should be made of each floor of the building from the architect's plans. On these should be noted the position of each fixture and its height from the floor, and the number of burners required for each one.

The number of burners and the kind of fixture may be conveniently indicated by the symbols shown in Fig. 5, where *A*, *B*, and *C* represent side lights or brackets having 1, 2, and 3 lights, respectively, each large dot representing one burner. In a similar manner, *D*, *E*, *F*, *G*, *H*, and *I* represent drop lights having 1, 2, 3, 4, 5, and 6 burners, respectively.

The horizontal piping should be indicated by plain black lines, and each floor plan should show only those pipes that are to be actually run in the floor of that story or on the under side of it.

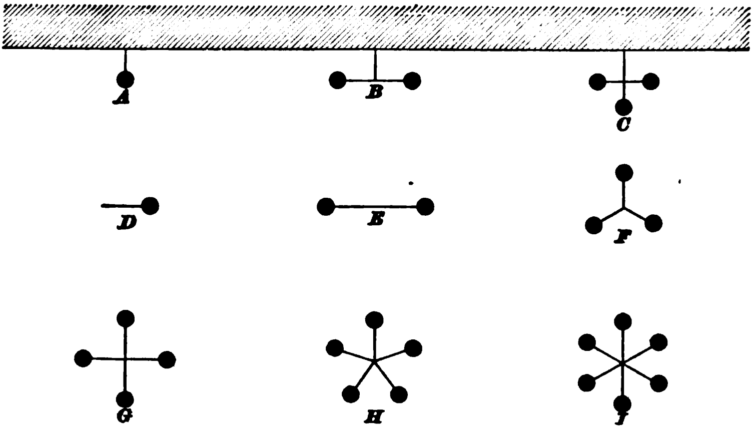

FIG. 5

The points at which risers or drop pipes are to be connected to the horizontal pipes may be indicated as shown in Fig. 6. Thus, an × at *j* indicates that a drop pipe descends from that point, and a ○ at *k* indicates that a

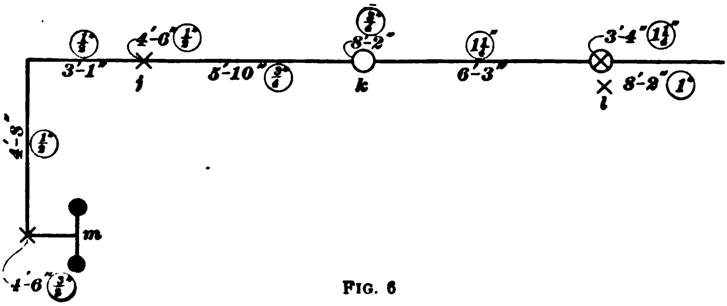

FIG. 6

riser ascends from that point. A ○ and × combined, as at *l*, indicate that the vertical pipe extends both above and below. At *m* is indicated a drop pipe leading to a bracket or side light having two burners.

The length of each pipe should be figured from center to center of fittings, and the diameter should be written close to the figures indicating the length. Thus, the pipe between *l* and *k* is shown to be 1¼ inches in diameter and 6 feet 3 inches between centers of fittings.

The length of each riser or drop pipe should be similarly indicated by figures placed near the symbol, and connected to it by a light line; thus, at *j* we have a drop pipe ½ inch in diameter, descending 4 feet 6 inches to center of fitting; at *k* we have a riser ¾ inch in diameter, ascending 8 feet 2 inches; at *l* we have a riser 1¼ inches in diameter, ascending 3 feet 4 inches, and a drop pipe 1 inch in diameter, descending 8 feet 2 inches.

In order to show which figures belong to the drop pipe at *l*, it is necessary to place an × before them, as shown. Where figures are crowded, it is advisable to draw a ○ around the figures indicating diameters of pipes, in order to clearly distinguish them from all others.

If any of the vertical pipes require to be offset or bent to pass around obstructions, etc., or a horizontal pipe requires to be run along a wall at a height between the floor and the ceiling, a reference letter should be placed conspicuously at that point, and a corresponding note made on the margin of the drawing. A diagram of the special pipe required should be made and attached to the drawing.

Gas-fitters' plans are sometimes made in perspective; but if the work is at all complicated, the drawing is likely to be very confusing, especially if the draftsman is a little unskilful.

The plan recommended above has the advantage that several sets of piping for various purposes may be indicated on the same drawing. Thus, pipes for gas, steam, and water, and tubing for electric wires, may be shown by using differently colored inks for the various systems of pipe.

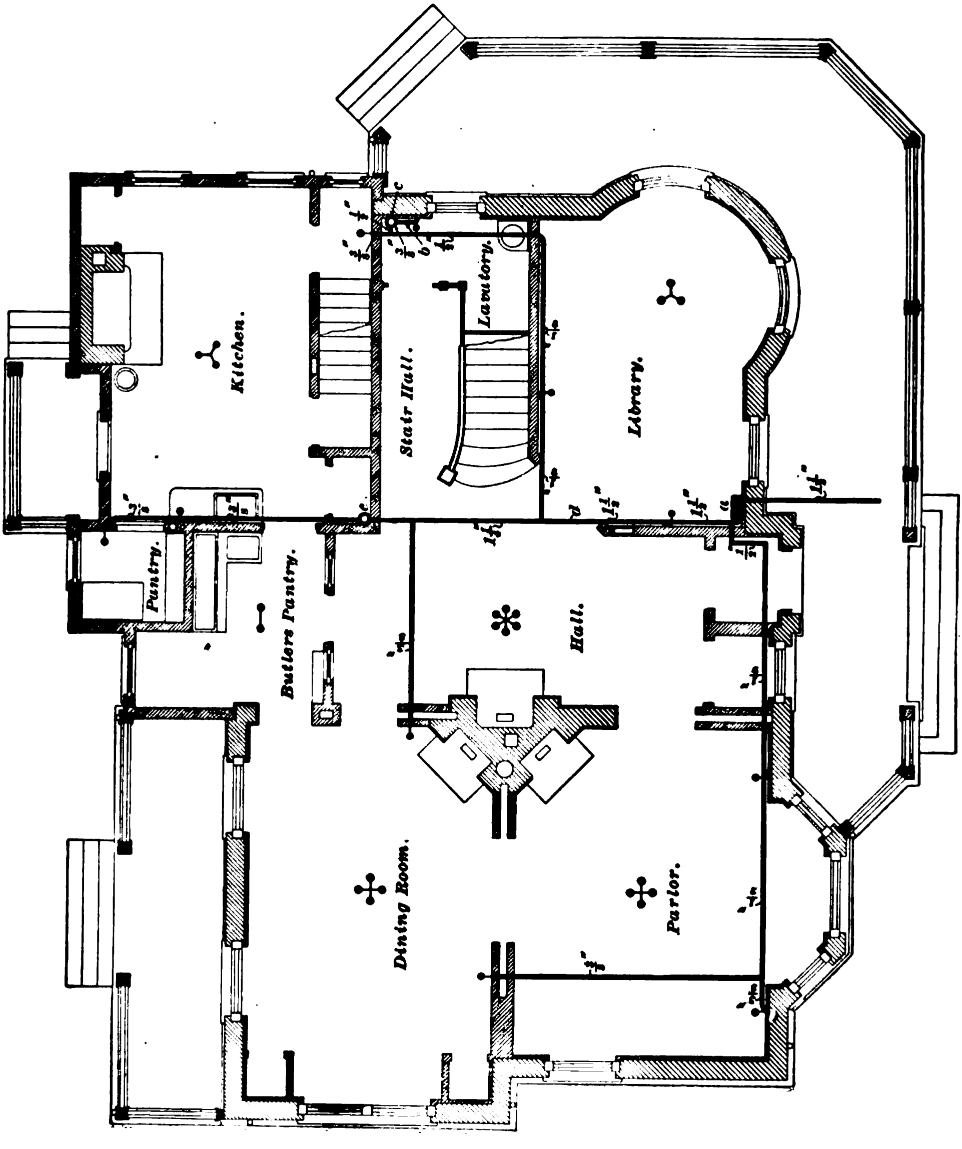
Kitchen.
Pantry.
Butlers Pantry.
Stair Hall.
Lavatory.
Library.
Hall.
Dining Room.
Parlor.
a
b
c
d
1¼"

FIG. 7

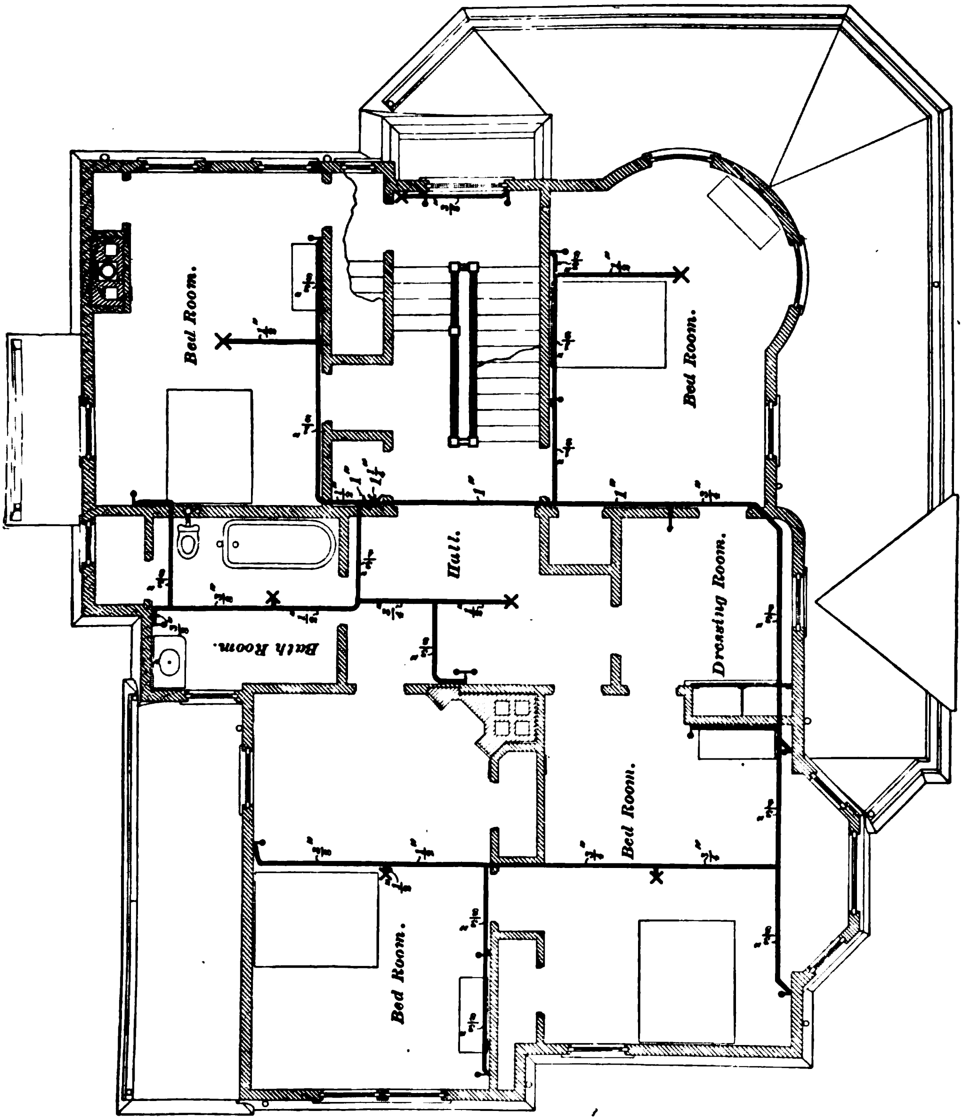
Bed Room.
Bed Room.
Hall.
Bath Room.
Dressing Room.
Bed Room.
Bed Room.
1"
1"
1"
1¼"

FIG. 8

16. Fig. 7 shows the first-floor plan of a common two-story and basement dwelling house. The second-story plan is shown in Fig. 8. These figures are supposed to represent tracings from the architect's drawings, with the gas piping drawn in.

The meter *a* is placed in the basement, and all the piping shown on this plan is run along or under the basement ceiling, except *b*, which is a ⅜-inch horizontal branch to supply the lavatory bracket from a ⅜-inch riser *c*, run from the basement to the brackets on the stair landing above. A distributing main *d* runs directly from the meter outlet to the riser *e*, and all the branches that supply gas to the brackets of the first floor, also the basement lights, are taken from this pipe.

The chandeliers or pendants that illuminate this floor are supplied with gas from the pipes shown in Fig. 8. These pipes run under the floors and across or between the joists. They also supply all brackets that illuminate the second floor.

The pipes are all proportioned to give an abundant supply of gas to the entire building when all the jets are burning at the same time. They are also all laid to pitch back toward the meter, where a drip cup may be placed. The piping in Fig. 8 is so arranged that no floor joists will be cut at a greater distance than 2 feet from a point of support. The joists all run from front to rear of the building.

There are many other ways of running the pipes for this work, but the drawings show a method probably as good as any.

17. If the location of the pipes is not shown by the architect, then the gas-fitter must use his own judgment in determining their position. He should be governed by the following considerations: (1) The pipes should run to the fixtures in the most direct manner practicable; (2) The pipes must be graded to secure proper drainage without excessive cutting of floorbeams, or otherwise damaging the building; (3) pipes that run crosswise of floorbeams should be laid not more than 1 foot away from the wall, so as to avoid serious injury to the floor by weakening the beams; (4) fixtures should be supplied by risers rather than by drop pipes, as far as practicable; (5) all pipes should be located where they can be got at for repairs with the least possible damage to the floors or walls.

SERVICE PIPES

18. The pipes that convey the gas from the mains into the building should be connected to the top of the street main, as shown in Fig. 9, and not to the sides or bottom. The hole in the cast-iron main is tapped with a drill and ratchet, held in place by a tapping machine or a clamp, often called a *crowfoot*, or *old man*. The best forms of tapping machine are now arranged with a saddle with a rubber gasket that clamps down on the pipe, and through which the drill or tap works. The escape of gas while the work is being done is thus avoided. The drill or tap is a combined drill, reamer, and pipe tap, so that the hole is tapped out in one operation ready for the fitting to be screwed in. Soap is used on the tap to prevent the escape of gas where machines that have no special device for this purpose are employed. Services should always be connected to the main by two street elbows, one being screwed into the hole in the main and turned in the direction of the run of the pipe, and the other being screwed into the first and turned toward the house. A form of universal joint is thus made, and there is no danger of straining or breaking pipe or fittings when the ditch is filled.

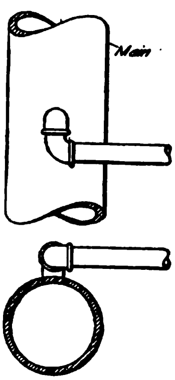

FIG. 9

19. Where it is desirable to run two services from the same tap to opposite sides of the street, a street tee *a*, Fig. 10, and two street elbows *b* and *c* are used, the street tee being screwed into the pipe so that the two ends look up and down the run of the main.

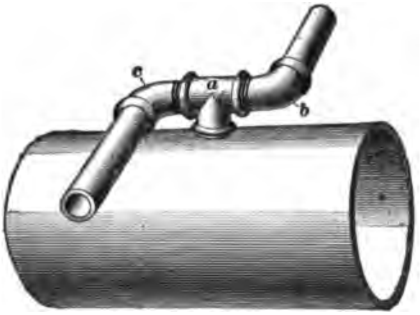

FIG 10

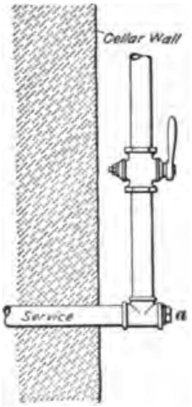

FIG. 11

20. A tee should be placed on the service at the first turn it makes after it comes through the cellar wall, as shown in Fig. 11, the fitting being so placed that the plug *a* can be removed and a wire or rod run into the pipe toward the main for clearing purposes.

21. Services should never be laid in a ditch above water or sewer pipes, as such a ditch is almost sure to settle enough to trap the service pipe. Where it is desirable to lay the service in the same excavation with other pipes, a shelf of solid ground should be left on one side of the ditch and the gas service laid on this, as shown in Fig. 12.

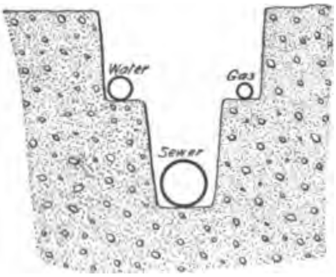

FIG. 12

22. Great care should be taken to lay service pipes with an even inclination toward the street main, if possible; but, if this cannot be done, then they should incline toward the house, in which case a suitable drip cup must be provided on the house end, as shown at *a*, Fig. 13. Services should be carefully bedded on firm ground, so that there will never be any chance of the pipe settling and forming a trap.

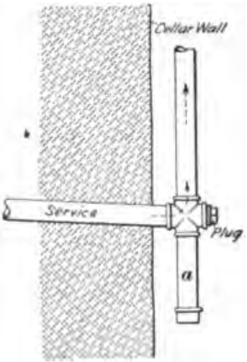

FIG. 13

23. A shut-off cock should be placed in every service pipe at the curb, and this should be enclosed in a suitable box extending upwards to the surface of the pavement, and closed against the entrance of dirt, water, or snow by a tight cover.

A curb box is shown in Fig. 14. A round-way stop-cock *a* is placed in the service pipe *b*. The service pipe is properly lined up and a brick support *c* is built under it, the pipe at each side of the stop-cock resting on the bricks. The rod *d* is made of such a length that its top end is about 2 inches below the surface of the sidewalk. The lower forked end of the rod is bolted to the key of the cock. The rod casing tube *e*, made usually of 1-inch or 1¼-inch pipe, is cut to such a length that, with the cast-iron cock casing *f* resting on the brickwork, the flange of the cast-iron curb box *g* finishes flush with the surface of the sidewalk. The square end of the rod *d* should project inside the box at least 1 inch, so that the rod may be turned by a box key. The cover of the curb box should be hinged, and preferably be capable of being locked. The casing pipe *e* should be screwed both into the curb box and the cock casing.

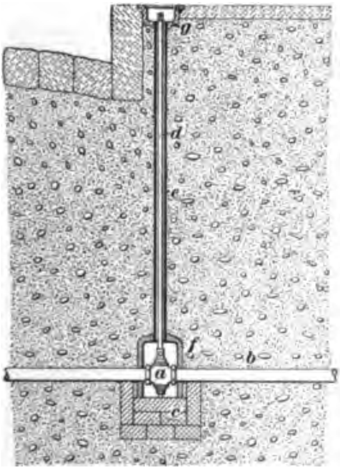

FIG. 14

24. The hole in the wall through which the service pipe enters the cellar or basement should be larger than the pipe, so that the settlement or shifting of the ground outside will not cause the pipe to bind or strain in the hole.

CONNECTIONS TO METERS

25. The connection from the meter to the service pipe and also to the house pipe should be made with lead or other soft-metal tubing, as shown at *a*, *a*, Fig. 15. These connections will bend and relieve the couplings on the meter from injurious strains in case the pipes expand or contract, or are displaced by the settlement of the building, etc.

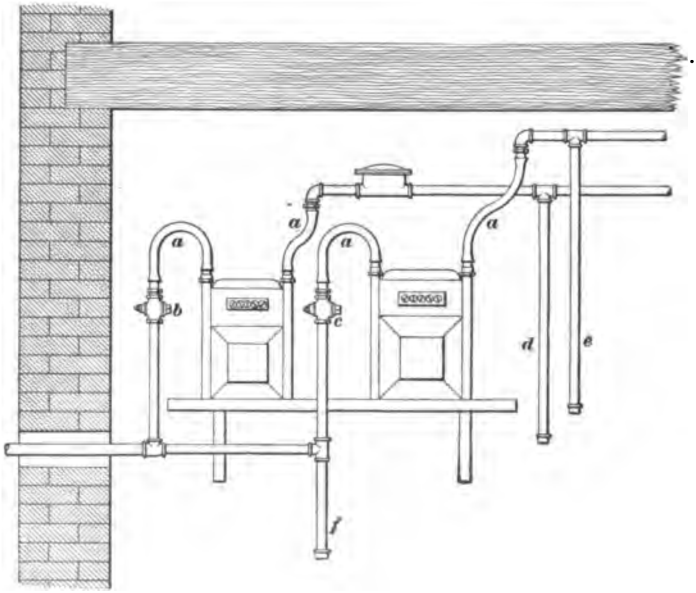

FIG. 15

Meters are usually set on a shelf, but this is not necessary unless the meter is large and heavy. If the meter is of the wet type, then it must be supported on a shelf, and the shelf must be carefully leveled both lengthwise and crosswise. The dry meters now in common use do not require leveling in order to work properly, but they should always be set plumb for the sake of appearance and as a matter of good workmanship.

26. A single service pipe may supply two or more systems of distributing pipes, as shown in Fig. 15. Each meter must be provided with a shut-off cock, as at *b* and *c*, and drip cups should be attached to each line of house pipes, as at *d* and *e*. The service pipe should also have a drip cup, unless it is inclined so as to drain into the street main. A drip for the service pipe is shown at *f*. If several meters are used in the same building, they should be placed on a shelf, in one group if practicable, and all the connections should be made exactly alike, so as to present a neat and orderly appearance. When gas is used for fuel in addition to lighting, it is often required that the two supplies be measured separately, in order to determine the actual expense for each purpose. Some gas companies furnish gas for fuel at reduced rates, to induce consumers to put in cooking apparatus, and also to increase the sale of gas. If the price of gas is the same for all uses, and it is not desired to keep a separate account of that used for fuel, then one meter is sufficient to measure the entire supply.

ORDER OF OPERATIONS

27. The proper way to pipe an ordinary building for gas is as follows:

The gas-fitter should visit each floor of the building with the plans in hand, and should mark the location of each drop for a hanging fixture, and of each side light or bracket.

Having thus acquired a clear idea of the location of each fixture, the next thing to be decided is the best route for the distributing pipes. If there are other pipes in the building, for water or steam or drainage, care should be taken to avoid conflict with them, and the risers for gas should be placed along with the other risers, unless they are an inconvenient distance away. Pipes for the various purposes of heating, lighting, etc. should not be scattered promiscuously over a building, but they should be kept together as much as practicable.

The matter of drainage should next be considered. Each branch must drain back into its riser, and the whole system should drain back to the meter. Long branches which run crosswise of the floorbeams should be avoided, because the notches that must be cut in the beams to give the necessary drainage become too deep and are then very objectionable.

Working plans of the piping on each floor should next be made for use at the pipe vise. The proposed route for each pipe should then be inspected to see whether the pipes can be got into place without difficulty, and whether right-and-left connections are required, and if so, where they must be placed.

The roads for the various pipes should next be marked off, taking the carpenter along and explaining to him the depth to be given to the notches, etc., and he should be fully instructed where and how to build the supports for the hanging fixtures. If the walls are of brick, the necessary pockets for rising pipes, if any, should be marked off, and the proper places for cutting holes through the walls, etc. should be carefully marked and shown to the mason.

28. Leaving the carpenter or mason to prepare the roads for the pipes, work may begin by setting up the pipe vise and getting the tools ready.

Each piece of pipe should then be inspected to see whether it is free from obstruction and dirt. The several pieces of pipe are next cut and threaded according to measurements on the working plan, and the fittings screwed on while the pipe is in the vise. The various pipes should then be carried to their respective floors and laid in convenient places.

Erection may begin by fitting up the main riser. The various branches should then be extended, working always from the riser toward the outlets. Cement or red lead should be used very sparingly, and care should be taken that no lumps or clots of it run down into the inside of the pipes.

Elbows, tees, and other fittings should stand clear from the studding and joists, whenever practicable, so that all the joints may be accessible for the purpose of testing.

Changes in the direction of small pipes should be made by bending the tube, if practicable, instead of using an elbow. Elbows and other fittings to which side lights or brackets are attached should be provided with flanges or lugs and should be firmly secured with screws to solid woodwork, or, in case of brick walls, to wooden plugs driven into holes drilled in the wall, or to wooden blocks imbedded in the wall for that purpose, so that the fixture will be rigid.

The nipple for a side light or bracket should project from the wall at right angles a distance of not less than ¾ inch, and not more than 1¼ inches. The nipple should be screwed tightly into the fitting, and a cap should be screwed on the outer end of it. This cap should be screwed up with only a moderate force, so that it can be easily removed at any time without danger of loosening the nipple from the fitting.

Drop nipples that are to support chandeliers or other hanging fixtures should hang perfectly plumb, and in case of a flat ceiling should project from ¾ inch to 1¼ inches from the surface. If ornamental center pieces of plaster, etc. are to be used, the necessary extra length of the nipple should be ascertained from the architect or contractor.

29. The proper manner of supporting a hanging fixture is shown in Fig. 16. The weight of the fixture is carried by the wooden block *a*, which must be made strong and be well secured to the joists *b*, *b*. The lower block *c* serves to guide the drop piece *d* and prevent it from swinging in any direction. Care should be taken to make the drop piece perfectly plumb.

30. When the nipples or drops for the fixtures are all in place, they should be tested to find whether they are square or plumb. This may be done by attaching a straight piece of pipe a foot or so long to which the square and level may be applied, or a plumb-bob may be used alongside of the piece of pipe.

31. The gas pipes should be placed in a new building as soon as the walls are up and the rough timbers of the floors and partitions set, but before the floors are laid or the lathing done. When a gas pipe runs parallel with the floor boards, as shown at *e*, Fig. 16, the board that covers it should have the lower flange of the groove removed, so that it can be readily taken up when desired. If the pipe runs crosswise of the floor boards, a loose piece should be provided in the floor over every principal elbow or tee, so that they can be got at easily in case of repairs or leakage. The loose boards and covers should be fastened in place with 2¼-inch screws. Brass screws are frequently used for that purpose, as they will not rust fast.

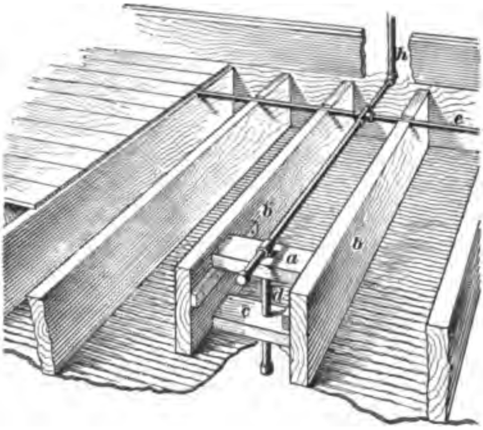

FIG. 16

EXPOSED PIPES

32. Gas pipes should not be exposed to the weather, if possible to avoid it, and care must be taken to protect them from freezing winds or air-currents. Moisture in the gas will condense on the interior of the pipe and form ice, and the deposit will increase in thickness until the pipe becomes choked. Exposed pipes should be covered with hair felt or other good non-conducting material, which should be made thoroughly waterproof by a covering of painted canvas. Good protection is especially necessary if the pipe contains carbureted air, which is usually gasoline gas.

Iron gas pipes should not be allowed to touch lead pipes or electric wires that run crosswise or near them, because the continual shifting caused by changes in temperature will ultimately wear a groove or thin spot in the softer pipe, and the insulation of the electric wire will be cut through, thus making a ground or short circuit.

If a metal pipe runs within 2 inches of an electric wire, they should be separated by a non-conductor of some description. For example, the pipe may be wrapped with four or five layers of rubber tape.

TESTING A SYSTEM OF PIPES

33. As soon as the pipes are all in place and are properly secured, the system should be tested to find whether it is perfectly gas-tight. The instruments used for this purpose are a *proving pump*, a *pressure gauge*, and an *ether cup*.

The **proving pump** is shown in Fig. 17. It is a single-acting piston pump having an inlet valve at the bottom that admits air under the piston, and an outlet or check-valve at *b*. The socket *a* of a special bracket is attached to a nipple on the pipe system that is to be tested. The pump is connected to the bracket by means of a stout rubber hose *c*, which must be wired to the coupling tails to prevent it from being blown off by the air pressure. The cock *e* serves to connect or shut off the pump from the pipe system, but does not shut off the gauge.

The **ether cup** consists of a small funnel on the bracket at *d*, which is closed by a thumbscrew. This is for the purpose of introducing ether to make a pungent odor in the interior of the pipes.

The pressure is shown by a mercurial gauge *f*, or by a common steam gauge *g*. The mercury column is to be preferred to the steam gauge, because its operation is positive at all times, and it always indicates the true pressure in the system.

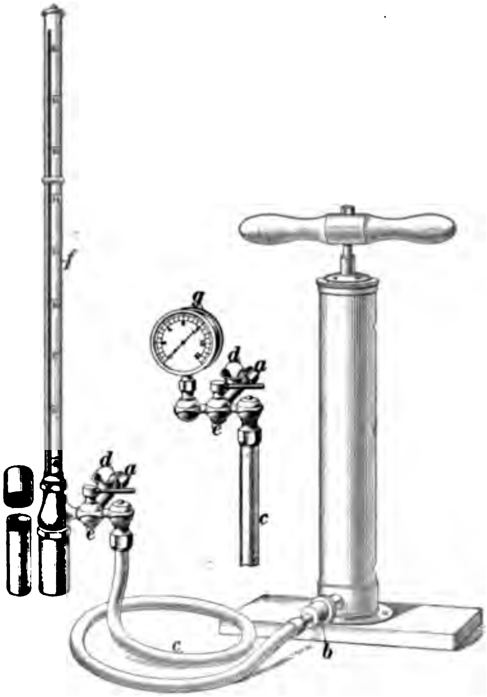

FIG. 17

Steam gauges, or similar contrivances, are not perfectly reliable pressure indicators, their moving parts being liable to stick fast, so that slight pressure variations are not always indicated on the dials.

34. To make the test, a convenient nipple should be selected for making an attachment to the proving pump; and every other nipple and open end should be tightly closed by screw-caps. Plugs driven into the ends of pipes will not answer the purpose.

The pump and pressure gauge may then be connected to the system and made tight. Air should be forced in until the gauge indicates 15 or 20 inches of mercury, or from 7 to 10 pounds per square inch. The pump should now be shut off, leaving the gauge under pressure. The pressure should be continued in the pipes for about an hour, and if the gauge shows a falling off in pressure of more than ½ inch of mercury, or ¼ pound per square inch, the system cannot be passed as perfect.

The extent of the leak may be judged by the rapidity of the fall in pressure, but its location must be found by the sense of smell. For this purpose, a small quantity of ether should be introduced into the pipes. The pressure gauge is usually provided with an ether cup especially for testing purposes. If none is at hand, a cap must be taken off somewhere near the pump and the pressure let off. The ether may then be poured directly into the pipe and the cap replaced as quickly as possible. The pressure should now be pumped up as before. The odor of the ether will diffuse throughout the system of piping and will escape from the leak; thus the location of the leak will be revealed by the smell of ether.

To locate the leak, it is necessary to go over the pipe system, carefully smelling each joint and suspected pipe or fitting. When a suspicious place is found, it should be daubed over with a thick solution of soap, and if any air is escaping at that point it will show itself by making soap bubbles.

Every leak that can be detected should be marked with chalk, and the pressure may then be let off. All defective pipes or fittings should be removed and replaced with perfect ones. Patching should rarely be permitted. However, if the defective fitting is a large one, and its removal will be very difficult and expensive, and the leak be but a small sand hole, it may be patched. Gas-fitters' cement, which is only a coarse grade of sealing wax, is not proper material for that purpose. The hole should be closed with solder; or, better still, the hole may be drilled out and tapped to receive a small screw plug. The drilling of the hole will reveal the character of the metal as to whether it is solid or porous. If it appears porous or spongy, the fitting should be thrown out and replaced with a sound one without further delay.

If fittings are cracked, they should in all cases be removed. Cracked or split pipes should always be removed; it is useless to try to patch them.

After making all required changes, the pressure should again be applied, the test being repeated until, with a pressure of at least 15 inches of mercury, the gauge will show not more than ½-inch loss per hour, as before described. If the system of piping is extensive, only one-half of that fall of pressure may be allowed. The gas-fitter should aim to have none at all, and on a really high-class piece of work, the mercury column should stand all night without showing any appreciable fall in the morning.

In case of large buildings, it is advisable to test the piping in sections, say one floor at a time, since in this way it is much easier to locate leaks. After each section is tested, they may be connected, and then subjected to a final test.

The pipes should not be covered until the tests are completed. Usually the gas companies or the city authorities require that the testing be done in the presence of their inspector. If no such regulations are in force, then the owner or architect should witness the tests, so as to avoid any possible disputes.

35. Ether is a dangerous fluid to handle, especially if there are any fires or lights in the vicinity. Cigars and pipes must be banished, and great care must be taken to avoid spilling any of it, or getting it on the hands or clothes, because if the odor is thus set free in the building, it will be difficult to detect leaks in the pipes. Other substances may be used that are free from the danger of fire, such as the essential oil of peppermint (not the essence), but they are not so volatile and do not diffuse throughout the pipes so readily.

DEFECTS AND THEIR REMEDIES

INTRODUCTION

36. The troubles experienced with gas-piping systems, and that gas-fitters are commonly called on to remedy, may be broadly divided into troubles occurring in the gas supply pipes and troubles with the fixtures, as the burners. Mainly those occurring in the gas supply pipes will be treated of here.

The most prevalent source of trouble are *leaks*, which may occur in any part of the pipe system or in the fixtures, and manifest themselves by a strong odor of gas. Leaks are liable to occur in the most unexpected places, and often require a careful, painstaking, and systematic search of the whole piping system within and without the building to discover.

Chokage of the supply pipes is another fruitful source of trouble; it is caused by foreign matter being carried into the supply pipes, and manifests itself by a reduction of the gas supply, as shown by the burners giving a steady but very small light.

Water in the gas supply pipes manifests itself by a flickering and jumping of the lights, which at times may be so bad as to render them almost useless. In extremely cold weather the water collected in sags and bends in the pipes may freeze and thus partially or entirely shut off the gas supply either from part or the whole of the building. The gas supply is then said to be **frozen up.**

LEAKS

37. Repairing gas leaks is dangerous business, because any mixture of common illuminating gas with air in the proportion of 13 parts of air or less to 1 of gas will explode if it comes in contact with fire of any kind. If the explosive mixture be richer in gas than 1 to 13, it will explode with proportionately greater violence.

Before entering a room that smells strongly of gas, all lanterns or torches must be extinguished, and cigars or tobacco pipes must be left behind. All matches should be laid aside, because the workman is liable, in a moment of thoughtlessness, to strike a light to "see where he is," and thus produce an explosion.

If the place is very dark, and a light is required, a coal-miner's safety lamp should be used. Even these lamps must be used with caution. The necessary instructions for handling them are furnished with the lamps.

Occasionally there is a risk of being suffocated or overcome by the gas, and the gas-fitter should always have an assistant within sight who can help him out in case of accident. If he begins to feel dazed or *queer* while breathing the vitiated air, he should drop to the floor and make his way out on hands and knees. The air near the floor is likely to be nearly free of gas, thus giving him a chance to breathe.

In beginning a search for a leak, the first thing to do is to shut off the gas at the meter, or, if that cannot be reached safely, it may be shut off at the curb. Then the windows and doors should be opened, and every effort made to free the premises from the presence and odor of gas.

All places that cannot be readily ventilated, such as the upper parts of closets, small hallways, space under stairways, etc., should be thoroughly fanned out, driving out the vitiated air into the air-currents that will carry it off. The space between the floors may be filled with gas, and sometimes it is necessary to make openings and circulate air through them to clear out the gas.

If the apparent proportion of gas in the air does not plainly diminish when the supply is shut off at the meter, then the leak is probably in the service pipe outside the building. It may be that the leak is in the main, and that the escaping gas follows the service pipe and enters the premises through the pipe hole in the cellar wall. In loose or made ground, the gas from a leak in the street will sometimes follow a water pipe into the cellar.

After the premises are cleared of the odor, the gas should again be turned on at the meter.

Ordinarily the leak can be located approximately by the odor of the gas that again escapes from it. If there is no plain indication of its source, then a systematic search must be made. The first point to be examined for leakage, in the system of house pipes, is at the meter. Leaks may occur in the meter casing or around the glass cover over the register dials. If a defect is found here, the meter should be removed and a sound one put in its place. A small leak may be stopped temporarily by the use of hard soap as a cement, but this cannot be depended on to remain tight for more than a few days. The meter connections should then be examined, and if the couplings are found to be leaking, they should be supplied with new packing washers. The gas' fixtures should next be examined, taking care to ascertain positively the tightness of every cock or key. Leaks may occur at the swing joints and at the base of the burners, but these will be perceptible only when the fixture is in use. Chandeliers and pendants should be examined at the connection to the drop nipple overhead, and at the ball joint, if there be one.

All stuffingboxes on sliding or extension fixtures should be closely examined. Leaks may also be looked for at either end of the nipple at brackets or side lights.

If no leak is found at the meter or fixtures, then the defect is evidently in the pipes or fittings, and the only practicable method of finding it is to prove the pipe system, as directed in Art. **34.**

The use of matches to detect small leaks of gas is a dangerous practice; they should never be used in any place where there is a chance for escaping gas to accumulate and mix with air. Smearing the pipe with thick soapsuds is more certain to reveal small leaks, and is free from danger.

If no leak can be found on the premises, and the odor of gas still exists, it is probable that the leak is in some other pipe system, and that the gas is conducted into the premises through some unsuspected channel, such as accidental passageways between floorbeams, rat holes, loose spaces around water pipes, etc.

CHOKAGE

38. When gas pipes become choked, they may be cleared in most cases by blowing them out with compressed air. An ordinary air pump is used to compress air into a strong storage tank, and when a sufficient pressure has been accumulated, the tank is connected to the choked pipe, and the air is discharged into it as suddenly as possible, thus blowing out all obstructions before it. The air pump and storage tank are generally combined into a portable hand-operated apparatus, one form of which is shown in Fig. 18, and is known as a **service cleaner.** The bulged part, or base, forms the air storage tank and has a hand pump attached to it by which air is pumped into the base. The stop-cock at the bottom is connected by means of a rubber hose to the gas-pipe system. Air having been compressed into the base, a sudden opening

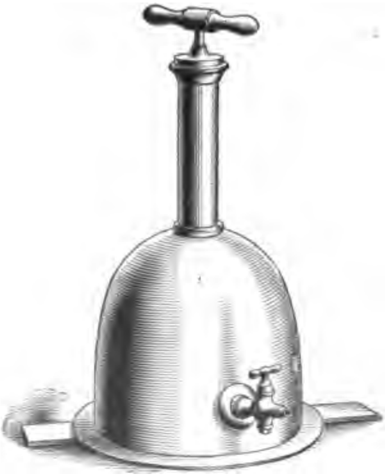

FIG. 18

of the stop-cock results in blowing suddenly a large volume of air into the gas-pipe system.

When a service pipe is choked, or trapped with water, it is disconnected from the meter, and air is quickly forced through toward the main. If the pipes in the building are choked, the gas fixtures affected by the chokage are taken down, and air is rapidly forced through their supply pipes, so that the obstructions will be blown out at the open ends of the drops.

FLICKERING LIGHTS

39. The flickering and jumping of gas lights is caused by the presence of water in the pipes. The liquid accumulates in sags and low places, and fills the bore of the pipe, forcing the gas through it in a series of bubbles. As each bubble escapes, the water is agitated, and the lights jump in response to the momentary fluctuation of pressure. This trouble can be remedied by emptying the drip cups and taking care to thoroughly drain all parts of the pipe system. Sometimes the deposit of water will be found in the fixture instead of in the supply pipes, especially if it be a pendant or chandelier. A water trap will frequently be found in the service pipe.

A similar effect is caused by a wet meter that is drowned or flooded by too much water. In this case the trouble may be overcome by drawing off the excess of water.

Dry meters that are stiff and need cleaning and oiling, or in which the arms have not been connected to the rock shaft at the proper angle, may cause the gas flames to flicker.

Dry meters are sometimes troubled with the water condensed in the pipes; they are usually provided with *trap screws*, so that the water can be easily removed when necessary.

The apparent freezing up or choking of the gas supply in extremely cold weather is due to the exposure of the pipe at some point to a draft of very cold air or to a freezing wind, the consequences of which were described in Art. **32.**

DOMESTIC USES OF GAS

(PART 1)

GAS LIGHTING

INTRODUCTION

COMBUSTION OF GAS

1. Ordinary illuminating gas is a mixture of several compounds of carbon and hydrogen, which vary somewhat in their composition. The process of combustion consists in the decomposition of these compounds by means of heat, and the formation of new compounds by combining the carbon and hydrogen separately with oxygen. The carbon and oxygen unite and form carbon dioxide (also called carbonic acid), which is indicated by the symbol CO_2. The hydrogen and oxygen unite and form water, indicated by the symbol H_2O, the water being in the form of vapor. A large amount of heat is given off during the formation of these compounds; but, owing to the mixed composition of ordinary illuminating gas, it is somewhat difficult to calculate the heat developed by its combustion.

2. If the composition of the gas is known, and the actual weight of a given quantity can be ascertained, then the heat in British thermal units may be computed by assigning to each pound of combustible substance the following amounts: Hydrogen, burned to water, H_2O, 62,000; carbon, burned to carbon dioxide, CO_2, 14,600; carbon, burned to carbon monoxide, CO, 4,400; carbon monoxide, burned to carbon dioxide, CO_2, 10,200.

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Before gas can be burned, its temperature must be raised to the point of ignition. A part of the heat produced by combustion is always absorbed in thus preparing the cold gas and air for burning. Combustion is not instantaneous in any case, because an appreciable interval of time is always required to bring the gas and air up to the required temperature.

3. The temperature of a gas flame depends on the amount of gas burned within a given space and time, and also on the temperature of the gas and air at the moment of entering the burner. Thus, if the size of a flame be reduced, the amount of gas burned remaining the same, the temperature will be correspondingly increased.

If a jet of gas be ignited in the ordinary atmosphere, the flame will spread out, until the surface presented to the air becomes large enough to take up the oxygen required for combustion with sufficient rapidity to consume the gas as fast as it issues from the burner. The surface of the flame thus extended is so large in proportion to the quantity of gas actually burning that the heat is radiated and imparted to the surrounding air with great rapidity, and the temperature of the flame is low in consequence. If the flame be a large one, some of the gas will become cooled below the point of ignition before it can secure the oxygen necessary for combustion, and will fail to burn. The gas unburned is not only wasted and lost, but it mingles with and poisons the air of the room in which the burner is used.

4. The temperature of a gas flame may be increased by placing a chimney over or around the flame. The supply of oxygen is increased by the draft thus created, and the size of the flame is reduced; or, if the supply of gas be increased, a greater amount may be burned in the same space. Another method that is very effective is to mix the gas with the air needed for combustion before burning it. Each particle of gas is thus supplied with all the oxygen required, and it burns as fast as the temperature can be raised to the point of ignition. The volume of the flame is thus reduced to a minimum, and consequently the temperature is raised almost to the maximum. The burners employed for this mode of combustion are called **atmospheric burners.** These burners are often called *Bunsen burners*, after the name of the inventor. A modification of the Bunsen burner is known as the *Fletcher*, which also is an atmospheric burner.

The proportion of air that must be mixed with gas to secure good combustion varies with the kind of gas used and also with the quality of the gas. Ordinary illuminating gas requires from six to twelve volumes of air to one of gas.

When the air or gas, or both, are heated before they are burned, the heat thus imparted is added to the ordinary heat of combustion, thereby increasing the temperature of the flame. If the preheating of the air or gas is accomplished by means of the waste heat of the gases of combustion, the process is called *regeneration*. This process is extensively used for producing high temperatures, and for lights of great intensity.

LUMINOSITY OF GAS FLAMES

5. The **luminosity** of flames depends on the manner in which the carbon is burned. Thus, when gas is burned in a good bat's-wing or Argand burner, light is emitted profusely; but when it is burned in an atmospheric burner, the flame appears pale blue and almost destitute of light. In order to understand the cause of the great difference in luminosity in these cases, it is necessary to examine the structure of the flames and note the different conditions under which the carbon is burned. Hydrogen, in burning, gives off an enormous amount of heat with very little light. It serves to produce light, however, by heating to incandescence the carbon that accompanies it, if any be present.

6. If the flame of a candle be observed, it will be seen to consist of four parts, as shown in Fig. 1. The lowest part *a* is of a bright blue color, and emits very little light. The central part of the flame, marked *CH*, is composed of gas generated from the material of the candle by heat, and it is dark colored and transparent. It is surrounded by a shell or envelope of yellow luminous flame, which is marked C and H_2O. Outside of this is another layer marked CO_2, which consists of hot gas, and is almost invisible. The greater part of the oxygen, which moves from the surrounding atmosphere toward the interior of the flame, is intercepted in the outer layer of hot gas, and is united with the carbon that escapes outwards from the luminous layer, thus forming CO_2. The remainder of the oxygen passes inwards into the luminous layer of the flame. Here it encounters the hot hydrocarbon gas that is passing outwards from the central space. The quantity of the oxygen is not sufficient to combine with both the hydrogen and the carbon. It combines with hydrogen easier than with carbon; consequently, the hydrogen is taken from the compound, leaving the carbon free and uncombined. The intense heat generated by the burning hydrogen raises the temperature of the free carbon so high that it becomes brilliantly incandescent. This is the only part of the process of combustion that generates light of any consequence. This incandescence endures only while the carbon is passing from the central part of the flame to the outer layer—a very minute interval of time.

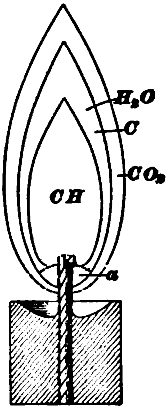

FIG. 1

The luminosity of the flame is thus seen to depend on the momentary existence of the carbon in a state of entire freedom, at a high temperature, under circumstances that deprive it of oxygen. The moment that it receives enough oxygen, it passes into carbon dioxide and ceases to be luminous. Thus, the carbon is burned only in the outer, non-luminous part of the flame, and only hydrogen is burned in the luminous part.

7. When gas is mixed with air and is burned in an atmospheric burner, each particle of carbon is accompanied with enough oxygen to convert it into carbon dioxide, and the hydrogen is similarly provided for. They burn simultaneously, the hydrogen forming water, H_2O, and the carbon passing directly from the original hydrocarbon compound into a new combination, CO_2. It is not for a moment detached and maintained as free carbon, as in the candle flame; consequently, the opportunity to become incandescent and luminous never occurs. Therefore, the flame of an atmospheric, or Bunsen, burner emits very little light.

8. An open gas flame will lose much of its luminosity if its surface is made too large. When the pressure is too high, the gas is projected so far into the atmosphere that a considerable part of it finds enough oxygen to burn its carbon and hydrogen simultaneously, as in a Bunsen flame. That part of the gas which burns in this manner fails to emit light of any consequence.

A gas flame will smoke when the area of its outer surface is so small that it cannot take up oxygen from the atmosphere with sufficient rapidity to oxidize the carbon as fast as it arrives at the outer surface of the flame. Only a part of the carbon can then be oxidized; the remainder cools below the point of ignition and passes off into the air as suspended carbon or smoke. The trouble may be remedied by increasing the area of the flame. This is usually accomplished by increasing the pressure of the gas. An artificial draft, such as made by a chimney or a fan, will also cure the smokiness by increasing the supply of oxygen to the flame.

9. The intensity of the light emitted by a flame of any certain kind of gas depends on the area of the surface of the flame, and on the temperature developed by the combustion. Thus, on comparing two burners that produce flames of different sizes while using the same pressure and volume of gas per hour, it will be found that the smaller flame will emit the most brilliant light. This result is due to the decrease of luminous surface from which light is radiated, which simply means a more rapid surface combustion per unit of area. Again, in comparing two flames that are alike except in temperature, it will be found that the hotter flame will emit the larger volume of light.

In comparing the light produced by burning gases of different compositions, it is found that the greatest light is afforded by the gas that has the largest amount of carbon in proportion to its hydrogen. Thus, acetylene, which has twelve times as much carbon as hydrogen by weight, gives about fifteen times as much light as an equal volume of average coal gas.

10. When gas is mixed with air before burning, the color and brilliancy of the flame undergo a great change. If common illuminating gas is used, and the maximum proportion of air is supplied, the flame will be very small and pale, having a bluish top and a greenish center. But, when the air supply is scant, the flame will burn with a dull yellow light, and will tend to smoke. As long as the yellow flame can be seen, it is certain that the proportion of air is too small.

Other gases give characteristic colors when burned. When free carbon is burned to carbon monoxide, CO, the flame is of a bright blue color, and when carbon monoxide is burned to carbon dioxide, CO_2, the flame shows a characteristic pink or rose color; but when the carbon is burned to carbon dioxide directly, the flame is nearly colorless.

METHODS OF PRODUCING LIGHT

GENERAL DESCRIPTION

11. All methods of producing light from gas or oils that are now in use depend on the incandescence of some substance that is exposed to the heat of the flame. In the flame of an ordinary gas burner, the light depends on the incandescence of the carbon, which exists for a moment in a free state. There are other materials, notably lime, magnesia, zirconia, and the oxides of several of the earthy metals, that emit far more light than carbon when they are heated to incandescence. These materials are used in the *calcium light*, the *oxyhydrogen light*, and in the *incandescent gas lamp*.

In the **calcium light,** a block of lime is raised to a very high temperature by means of a strong blowpipe that is supplied with a mixture of common illuminating gas and air. The lime becomes incandescent and emits light of great brilliancy.

In the **oxyhydrogen light,** pure oxygen and hydrogen are burned at the blowpipe, instead of ordinary illuminating gas and air. The heat of the flame thus produced exceeds all other known temperatures, and it causes the lime to glow with the most intense brilliancy.

Incandescent gas lamps are variously constructed, but all operate on the same principle. Any kind of combustible gas, or even oily vapor, is mingled with air and is burned in an ordinary atmospheric, or Bunsen, burner, with the object of producing the greatest practicable heat. The flame is directed against the inside of a fine circular netting, which is composed of platinum wire, or of threads of magnesia, zirconia, or similar oxides of the earthy metals. The netting becomes incandescent, and emits light of high intensity.

GAS-LIGHTING BURNERS

12. Plain Burners.—A gas burner consists of two parts: the *tip* and the *pillar*. The **tip** is the part having the orifice or orifices from which issues the gas to be burned; the **pillar** is a socket threaded at the bottom with a standard thread to fit gas fixtures, and carrying the tip at the top. In the very cheapest and poorest burners the pillar and tip are one piece of metal; in the better and more satisfactory burners the pillar is of brass and the tip of some refractory substance, generally steatite. The combination of the tip and pillar is known as a **plain gas burner.** There are two forms of plain burners, known in accordance with the shape of the flame produced by the tip, as *fish-tail burners* and *bat's-wing burners.*

13. The tip of a common **fish-tail burner,** which is also known as a **union-jet burner,** is shown in Fig. 2. The gas issues from the orifices shown, in two round jets, which collide and spread out into a flat two-pointed flame of the general shape shown at *A*. This shape is not so favorable to the development of light as that given by other forms of burners. When the holes become fouled by deposits of soot, the light becomes dim through the reduction in gas supply.

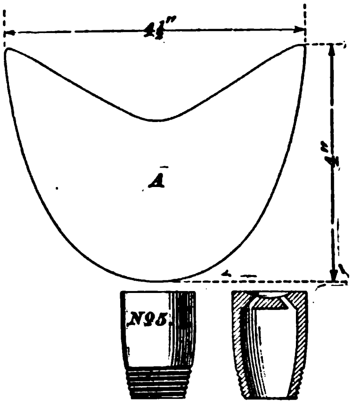

FIG. 2

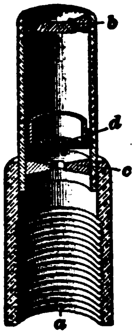

FIG. 3

14. A very satisfactory form of fish-tail burner is the **Bray special burner,** shown in section in Fig. 3. It consists of a brass pillar *a*, a union-jet steatite tip *b*, a steatite gas check *c* with a small central hole, and woven cloth screens, four or more in number, at *d*. The size of the mesh of the different screens varies, the coarsest mesh being at the bottom and the finest at the top. The volume of gas is checked at *c*, and the flow is steadied by the screen. The amount of gas that this burner will consume under ordinary pressures and to the best advantage is marked on the outside of the pillar.

15. A good form of a plain burner is the **bat's-wing burner,** shown in Fig. 4. The head of the tip is hemispherical, and the gas issues through a single straight slot that spreads it out into a thin flat sheet of flame of the general shape shown at *B*. These burner tips are sometimes made with two curved slots, as shown at *A*, but they are necessarily so thin and the slots so narrow that the tips are very easily clogged and broken.

The capacity of these burners, in cubic feet of gas per hour, is marked either by figures stamped on them or by means of grooves cut around them—one ring for each cubic foot. These marks serve to show the capacity only in the most general way, and cannot be relied on for accuracy.

16. Argand Burners.—The particular design of burner shown in Fig. 5 is called an **Argand burner,** from the name of its inventor. The burner consists of a hollow ring *a*, which is attached by two hollow arms *b* to a socket *c*, threaded to screw on to an ordinary burner nipple. The gas issues from the interior of the ring through a series of small holes, as at *d*, and the jets all unite to form a complete circle of flame. A plentiful supply of air passes through perforations in the chimney holder *e* and also through the central hole of the burner. The volume of the gas passing through it is regulated by a screw *g*, which has a very quick pitch, requiring only about one-third of a revolution to nearly close the valve *h*.

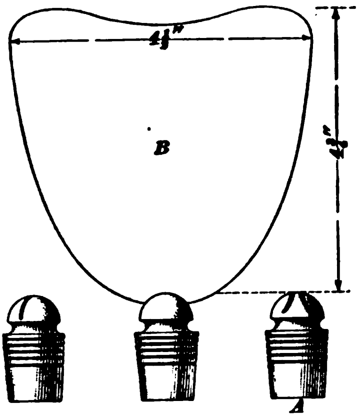

FIG. 4

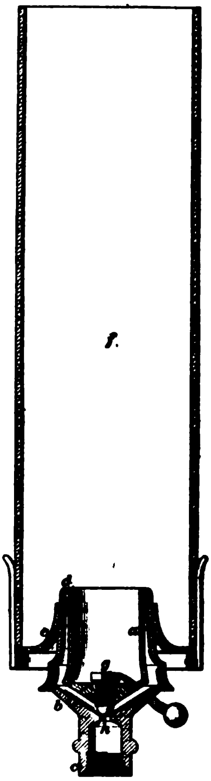

FIG. 5

In order to secure the best results with this burner, the gas pressure should be about .2 inch of water, and the chimney *f* must be of such diameter and length that the draft will supply the proper amount of air to completely burn the gas—no more nor less. This amount will vary somewhat with different qualities of gas.

Every Argand burner should have a volumetric regulator. Without it they are liable to be wasteful, while if they are properly regulated and adjusted, they will burn gas very economically.

17. Fig. 6 shows a large *compound* Argand burner, having two burner rings *k* and *l* and a single jet *m* in the center.

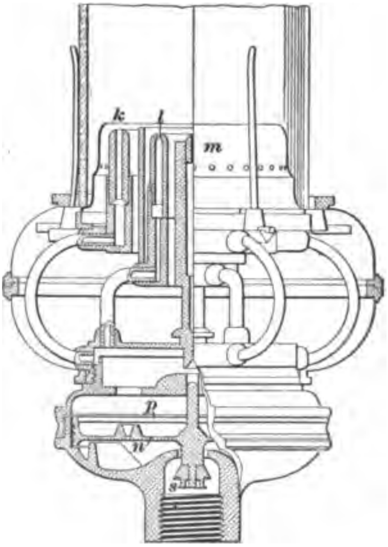

Fig. 6

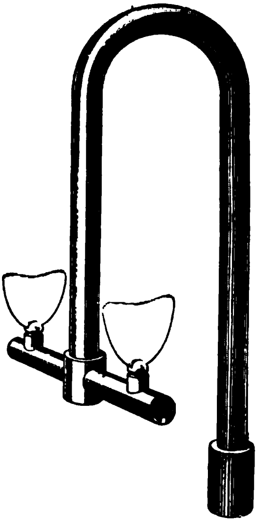

Fig. 7

This kind of burner is made with three, and even four, burner rings, the latter size serving to produce a light of 400 candlepower. All compound burners are supplied with a volumetric pressure regulator, as shown. The gas passes through fixed orifices *n* in the floating governor disk *p*. The movement of this disk opens and closes the throttling valve *s*, and thus controls the volume and pressure of gas passing to the burner.

18. Regenerative Burners.—The regenerative lamp or burner is made in many forms, the object in every case being to heat the air or gas, or both, before the gas is burned. This principle has been applied also to gasoline burners and common petroleum lamps. The simplest application of the regenerative principle is shown in Fig. 7. Two or more small bat's-wing burners are supplied by a pipe that descends close to the flames and that is heated by them. The gas is thus heated before it is burned, and the temperature of the flame is increased accordingly. Even this crude application of the principle of regeneration produces a perceptible increase in the brilliancy of the lights.

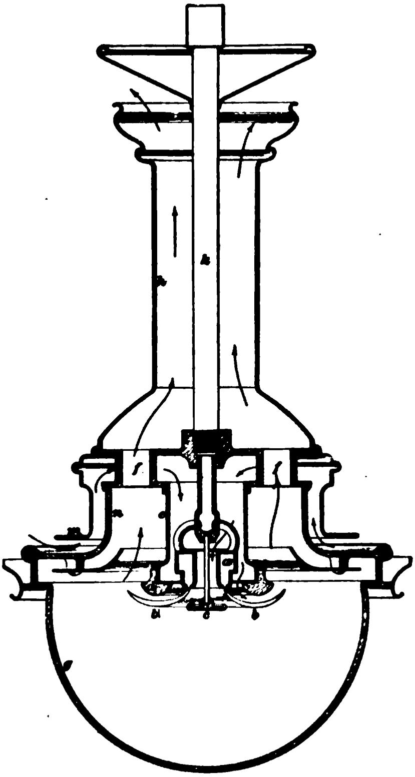

FIG. 8

19. In the *Wenham* lamp, shown in Fig. 8, both the air and gas are heated before combustion. The burner *a* is an inverted ordinary Argand ring, that is, having the jets of flame on the bottom end. The flames *b* are turned outwards by a deflector *c*, and they curve over the rounded surface of a porcelain ring *d*, thus forming a broad horizontal ring of flame of great brilliancy. The lamp is closed tightly against the entrance of air below the flame by means of the glass hemisphere *g*. The hot products of combustion pass upwards around the tube *e* through a number of tubes *f*, and up the chimney *h*. The gas passing down the tube *k* is highly heated before it reaches the burner. The air required for combustion enters between the cap *m* and the shell *n*, passes between the hot tubes *f*, and thence downwards through the tube *e* to the Argand burner. This construction is said to increase the amount of light given off from three to four times above that produced by good bat's-wing burners using the same quantity of gas.

20. The *Lebrun* lamp, shown in Fig. 9, employs a peculiar burner. The lamp is enclosed within a glass globe *g*, and all the air required for combustion is taken in through tubes *a* that connect *d* with the atmosphere. The air is heated by passing through these tubes and the central chamber *d*, which parts are exposed to the upward current of hot products of combustion. The gas burner *k* is an ordinary bulb, or rose, burner, and the flame is spread out into a convex disk of great brilliancy by means of the current of hot air that flows through the wire gauze disk *e*. The conical frustum *c* serves to concentrate the hot gases of combustion on the sides of the air chamber *d*. The draft is augmented by means of the chimney *h*. The burner is supported by a pipe *l*, and the lamp can be attached to ordinary fixtures by the socket *m*.

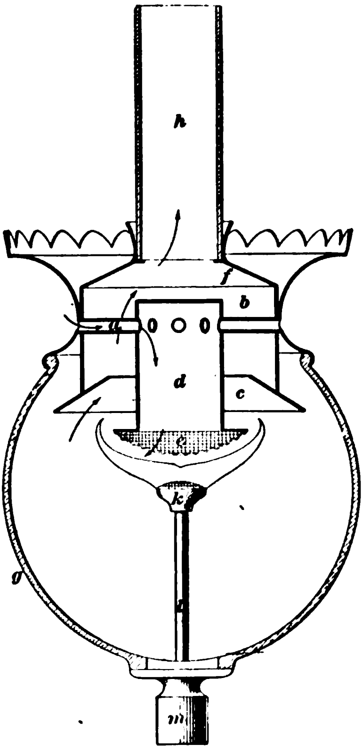

Fig. 9

21. Incandescent Burners.—The incandescent lamp is made in various forms by different concerns, but all operate on the same general plan. The *Welsbach* lamp, shown in Fig. 10, is a good representative of the class. An ordinary Bunsen burner is employed; the gas enters at *a* and the air at *i*. The mixture burns on the top of the wire gauze cover *b*, producing great heat but little light. This heat is transformed into light by means of a hollow tubular network *c* suspended over and around the burner by a wire support *d*. This network, or *mantle*, is composed of threads of incombustible material, which become brilliantly incandescent when highly heated, and thus convert heat into light. The light emitted from the base of the mantle is so brilliant that it is painful to look at directly; therefore, such lamps, if intended for office or domestic use, should be provided with a shade *e* of white or opal glass, to modify the intense glare.

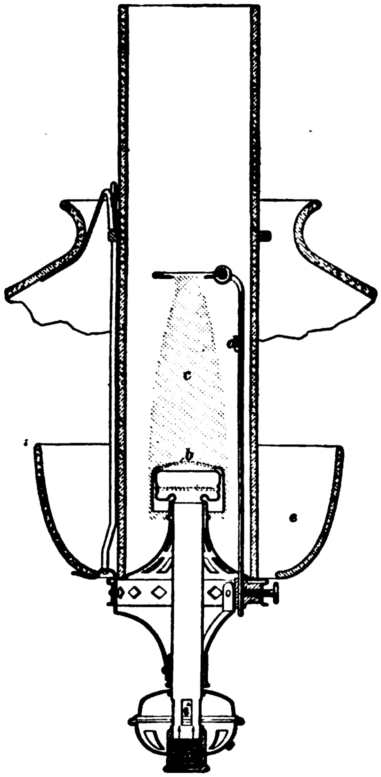

FIG. 10

22. Mantles have been made of many different kinds of material, notably of platinum wire, but the most successful are now made by saturating a delicate woven cotton fabric with a dense solution of several of the earthy oxides, such as magnesia, zirconia, thoria, etc. The mantles are then baked and carefully packed in individual boxes for shipment. Before subjecting a mantle to the heat of a Bunsen flame, its temperature is raised high enough to destroy the cotton fibers, leaving the coating of oxides standing as a network of fragile crust. This burning-out process is accomplished by applying a lighted match to the mantle when it is in place. The fragility of the mantles is at the present time the chief drawback to this mode of gas lighting.

The Welsbach lamp is not limited to the use of illuminating gas. Any kind of combustible gas, oil vapor, or gasoline may be used, by providing a burner capable of heating the mantle to the proper degree.

Fig. 11 shows a Welsbach incandescent lamp adapted to burn gasoline. Lamps similar in construction are made to burn common kerosene.

23. The candlepower of mantles depends, of course, on the quantity and quality of the gas, the manner in which it is consumed, and also on the size and quality of the mantle. The mantle commonly used is estimated to produce about 60 candlepower when new, using about 3 cubic feet of gas per hour. Small mantles of about 20 candlepower are furnished for small burners that consume about 1 cubic foot per hour. Large mantles giving about 100 candlepower can also be obtained. Some of the best mantles on the market are estimated to give, when new, from 30 to 40 candlepower per cubic foot of gas consumed per hour. If a mantle is located in a dusty atmosphere, it loses in lighting power by the dust that clings to it, and which cannot be removed without injuring the mantle.

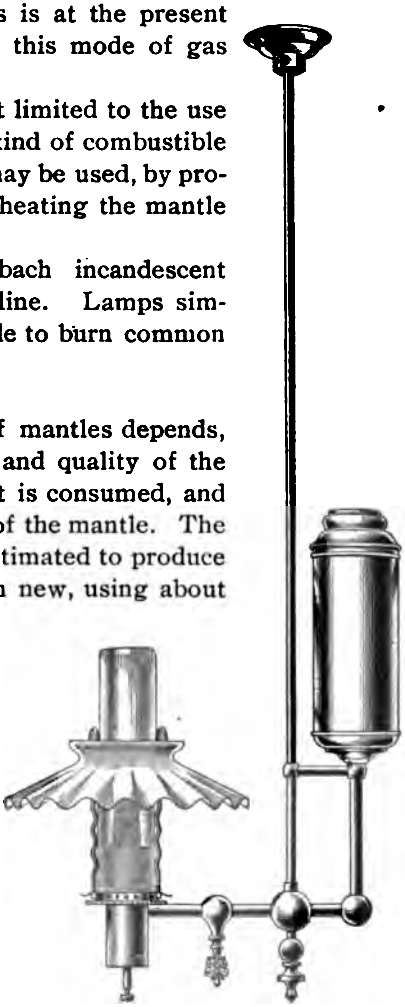

FIG. 11

24. The actual saving effected by the use of incandescent burners can only be found by replacing the common plain burners with incandescent burners and keeping a record. If the total amount of illumination is the same in a given building with incandescent burners that obtained previously with plain burners, the gas bill should be reduced to at least one-fifth the previous ones per month. This condition, however, may be said never to exist in practice, since people prefer more light, as a general rule, than is obtained from ordinary burners. A saving of 50 per cent. may in practice be considered to be a fair average for all ordinary cases.

25. The life of an incandescent mantle depends on its composition and the usage it receives. Cheap mantles may be estimated to give a good light for about 200 hours, while the more costly mantles may be estimated to give a good light for 600 hours. If they burn at an average rate of 3 hours per night, then the cheap mantles should last at least 7 weeks and the more costly ones at least 20 weeks. Owing to defects in manufacture, and carelessness in handling them, or accidental jarring of the gas fixture, many mantles will not last the time specified; but, on the other hand, a number will last longer.

26. The gas pressure for incandescent burners should not be less than 1 inch. If the pressure is much higher than this, it must be regulated either automatically or by hand. Some of the modern burners are provided with gas checks that are adjusted to suit the pressure in such a manner that the exact amount of gas will flow into the Bunsen tube of the burner. Fig. 12 (*a*) shows in elevation and Fig. 12 (*b*) in section a Bunsen tube with an adjustable gas check. The lower end of the socket *a* is tapped, and screws on to the gas fixture. The check is located at *b* and is formed by a perforated shutter, as shown, that rotates on a central pin, and is moved by moving the lever *c*. If the gas pressure is low, the check is fully opened so that gas is passing through each perforation, but if the pressure is high, the lever is slowly moved so that the shutter will close some of the holes. This is done while the gas-cock is open fully. When the gas supply is thus checked, the proportions of air and gas consumed are such as should insure a good light so long as the pressure in the pipes remains nearly constant; this also overcomes the necessity of the operator checking down the gas-cock every time the burner is lighted.

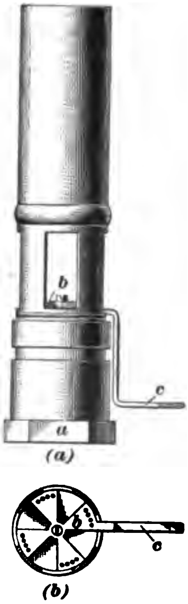

FIG. 12

If the gas supply is too great, a yellow flame will be visible at or over the top of the mantle. The gas supply should then be checked down and the air supply increased until the exact proportions are obtained. If the gas supply is too small, and the air supply sufficient to prevent a yellow cap on the flame, the upper part of the mantle will be dull, perhaps red, and the lower part only will be incandescent. The air supply to incandescent burners must be carefully adjusted so that the exact amount of air will mix with the gas in the Bunsen tube. If too little air enters the tube, the top of the mantle will become blackened by a deposit of carbon and only the lower part of the mantle will become incandescent. The carbon will, however, slowly disappear when more air is admitted. If the air supply is too great, the flame will become cooled and the incandescence of the mantle will be reduced. The best lighting result is secured when the supplies of air and gas are adjusted so that the mantle is brilliantly incandescent from top to bottom, while there is no noise, nor any flame visible on top of the mantle.

27. Economy in Lighting.—The light emitted per cubic foot of gas consumed per hour by burners of different types varies with the type and also with individual burners of the same type, the variation in the lighting effect in the latter case being due chiefly to lack of care in the management of the burners. Union-jet and bat's-wing burners will average from 2 to 3 candlepower per cubic foot of gas per hour; regenerative burners will average between 5 and 8 candlepower; and incandescent burners will average between 10 and 30 candlepower.

28. Many persons waste gas by turning on too much of it, in cases where the gas is delivered at a high pressure. This is clearly shown by an examination of Table I, which gives the results of experiments conducted with a 4-foot union-jet burner.

TABLE I

CANDLEPOWER OF 4-FOOT UNION-JET BURNER AT DIFFERENT PRESSURES

Gas Pressure Inches of Water Column	Gas Consumed per Hour Cubic Feet	Light Emitted per Cubic Foot in Candlepower	Candlepower of Flame
.5	3.90	3.00	11.70
1.0	5.60	2.40	13.40
1.5	7.00	1.90	13.30
2.0	8.45	1.50	12.67
2.5	9.60	1.35	12.96
3.0	10.50	1.11	11.65

The table shows that, with the burner tested, the highest efficiency was obtained with .5-inch pressure. Experience has shown that this pressure proves satisfactory for other burners. If the gas pressure in the pipes is higher than this, the pressure at the burner must be reduced either by a governor or by closing the gas-cock until the desired pressure is obtained.

The correct pressure for a gas burner can be determined quite closely by the shape of the flame. When the pressure is too high, the flame will flare, show a ragged edge, as illustrated in Fig. 13 (*a*), and make a hissing noise; the key in the gas fixture should then be turned slowly to check the gas pressure until the flaring disappears. When the gas pressure has been properly checked, the flame will be silent, bright, and steady, assuming the form shown at (*b*). When the flame thus appears, the greatest amount of light is obtained for the least gas consumption; that is, the burner is then burning the gas at the point of maximum efficiency.

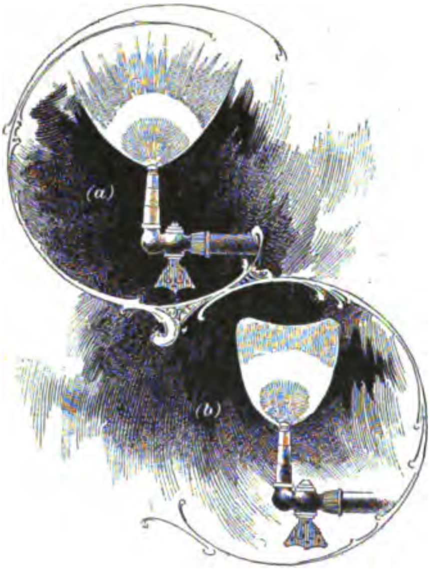

FIG. 18

TROUBLES AND REMEDIES

29. When the gas-fitter is requested to inspect the gas-lighting apparatus in a dwelling or other premises and to put in good order everything that appears to require improvement, in the hope of reducing the consumer's gas bills, he should begin by ascertaining whether the various burners are supplied with gas at a sufficient pressure. This can be done by lighting all the burners that are ever in use at the same time, including all cooking and heating burners, if any. The appearance of the flames will show whether the supply pipes are large enough; if still in doubt, the water gauge should be applied.

If the pressure appears to be too low, it may be due to the fact that there is a pressure reducer or governor at the meter that is improperly adjusted. Sometimes these governors become fouled, causing considerable resistance to the passage of gas. By opening the governor valve to its full width, or by removing the governor temporarily, it can be quickly ascertained whether the lack of pressure is due to the smallness of the pipes or to the resistance of the governor. Sometimes the trouble is due to a defective meter.

The condition of the meter can be judged by applying two water gauges—one on each side of it. Then, if the gauge on the house side of the meter shows a much smaller gas pressure than the gauge on the service side, the meter is defective and should be replaced or repaired.

Each burner may be supplied with a volumetric regulator if the pressure is irregular. These regulators save much more gas than a pressure reducer, and it is generally advisable to attach them.

If any atmospheric burners are used for cooking and heating purposes, the governor at the meter should be adjusted to give the pressure most suitable for their use, leaving the volumetric regulators to take care of the illuminating burners.

If there is no governor on the system, the pipes leading to the stoves should be supplied with one. The burners should be closely inspected and cleaned. Each burner should be provided with a compound cock that adjusts the air and gas inlets at the same time, and the cock should be so adjusted that the proportions of air and gas are at all times the highest that can be used without snapping back.

Attention should be given to the condition of the illuminating burners. The flames should be as large as practicable and perfectly steady, without flickering or hissing. The outline of the flame should be smooth and free from wavering tongues or deep notches. The color should be as nearly white as practicable. If the flame is yellow or dull, suggesting smokiness, it shows that it is not spread out sufficiently; the tip should then be replaced with a new one having a thinner slit.

The smoking of open gas flames, as given by union-jet and bat's-wing burners, may be due to defects in the burner or to excessively rich gas. Smoke is produced when the supply of air is too small to burn the carbon in the gas.

If the tip fails to spread the flame sufficiently to secure the necessary oxygen for good combustion, the burner will smoke. The defect may be in the tip, or it may be that the pressure is reduced too much by a check in the interior of the burner. The proper remedy is to provide a new tip having a thin, clean slot, and if that does not properly spread the flame, then the check should be readjusted or removed so as to increase the pressure.

If the gas smokes because it is extra rich, the trouble may sometimes be remedied by providing the burner with a glass globe, or by using a burner having a chimney, or by using incandescent burners.

The question of illumination should also receive attention. Frequently several small burners are used to light a room, when one or two large burners would give more light with a smaller consumption of gas.

Gaslights that are used only a few minutes at a time and are turned down during the intervals, as in bathrooms, water closets, cellar stairways, etc., are usually very wasteful of gas, and a saving can be made by employing self-lighting burners in all such places.

The gas-fitter should advise the removal of all open-flame burners and the adoption instead of incandescent burners with good mantles, except in places where the mantles are liable to receive rough usage. Some persons, however, are prejudiced against mantle burners on account of the apparently greenish color of the light, and also because a breaking of the mantle leaves them without light until the mantle is replaced. In the latter case it is advisable to recommend replacing one-half of the open-flame burners in the living rooms with mantle burners, keeping the open-flame burners in reserve, to be used in case of breakage of mantles.

It is to the interest of the consumer that all the lighting and heating burners on his premises be thoroughly inspected and put in good order at least once every year. When the inspection is made annually, it requires but little time, and the cost is small compared with the saving that will usually be made in the gas bill.

30. Where the ceilings are low, and consequently near the burner, they may become discolored, although not actually scorched. Each gas flame causes an upward current of hot air, which ascends until it reaches the ceiling. This produces a circulation of the air within the room, and particles of dust in the current will be carried to the ceiling at a point directly over the burner; consequently, that part of the ceiling soon becomes discolored by the dust that adheres to it. The discoloration is usually charged to smoke from the gas, but it is mostly due to the stream of dust. If the gas does actually give off smoke, it will aggravate the trouble, but that can be easily remedied by providing a proper burner.

The trouble may be mitigated, although not wholly cured, by using a deflector, as at *a*, Fig. 14, or by hanging an ordinary smoke-bell over the flame. By spreading out the current, its velocity is checked, the amount of dust that strikes the ceiling within a given area is reduced, and the discoloration is lessened.

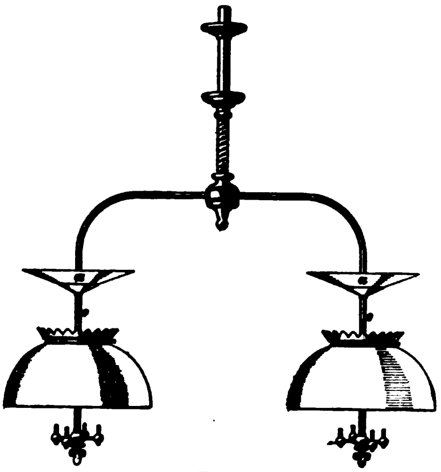

FIG. 14

The only effectual method of preventing the discoloration of walls and ceilings in this manner is to intercept the current of hot air arising from each burner, and to conduct it to a chimney or ventilating flue by means of a hood suspended over each flame, or set of flames, and suitable pipe connections. This plan is valuable for another reason: Not only are the products of combustion removed from the room, but a considerable amount of air is carried along also, thus aiding ventilation. The hot gas that is discharged into the ventilating flue raises the temperature therein, and thus increases the draft and improves the operation of the flue.

GAS FIXTURES

GENERAL CONSTRUCTION

31. Nomenclature and Classification.—The term **fixture** is applied to the apparatus that supports the gas burners and serves to connect them to the supply pipes. Fixtures divide into three general classes: *brackets*, or *side lights*, which project from the walls; *pendants*, or *chandeliers*, which hang from the ceiling; and *pillar lights*, which stand on a base, such as a mantel, a table, or a newel post.

Brackets made without joints are called *stiff* brackets, and those having flexible joints are called *swing* brackets.

All fixtures that hang from the ceiling may properly be called pendants; but, as commonly applied, this name is restricted to fixtures carrying one or two lights, and that are of plain construction. If the number of lights is greater, or the construction is decidedly ornamental, the term chandelier is used instead. This name is applied to the fixture without regard to the variety of lights that it carries, whether candles, kerosene lamps, gas burners, or electric lamps. The terms *gasolier* and *electrolier* have been devised to distinguish a chandelier bearing gaslights from one carrying electric lamps, but these terms have not come into general use.

There is another class of fixtures called *sunlights* and constructed in a great variety of ways. They are used chiefly to produce a great amount of light near the top or ceiling of large audience rooms, and also to furnish copious illumination for show windows, etc. A sunlight consists of a large group of small gas burners attached directly to the supply pipe and a reflector that is adapted to throw the light downwards as much as possible. The group is made up in a circle, or sometimes in a rectangle or in parallel lines. The burners are usually set so close together that when one is lighted it will ignite the adjoining jets, and thus light up the whole group. The flames, however, should not touch one another when burning.

Ornamental fixtures are usually built over a frame or skeleton of plain brass or iron tubing. The ornamental part consists of thin tubes, or shells, of brass, which are slipped over the main tubing, and are bound in place by screwing the various fittings tightly together.

32. Gas-Cock.—The most important part of any fixture is the **key**, or **cock**, by which the gas is turned on or off. The safety of the inmates of the rooms from poisoning or suffocation, or from injury by explosions of gas, requires that the key of every fixture be properly constructed, and also that it be properly adjusted. If a key is loose in its socket, it is very liable to be opened accidentally, or to be reopened unintentionally in the act of removing the fingers after closing it. A loose key is so dangerous that it should not be permitted to remain thus under any circumstances.

The proper construction of a key is shown in Fig. 15. The plug *a* should be tapered, and should be ground into its seat until it has a perfect bearing throughout the whole length of the socket. It should be held in place by means of a washer *b* and a screw *c*. The washer should have a central hole, as *d*, with one or two straight sides, and it should fit over the flat-sided end of the plug without looseness or play, so that when the plug turns the washer will turn with it. If there is any play at this point, it will tend to loosen the screw *c* and thus spoil the tightness of the key. It is a very common mistake to make the dimensions of the washer and screw too small, causing the washer to wear loose quickly when the screw is properly tightened up. The head of the screw should always be made large enough to afford a good hold for a screwdriver. Keys having small thin washers, or screws with small shallow slots, should be rejected. There should always be some

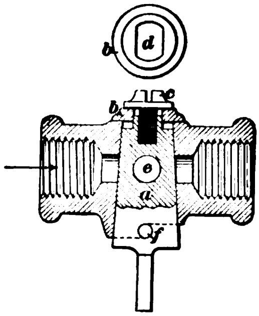

FIG. 15

clearance under the washer and under the screw head, so that when the screw is tightened up they will never come to a bearing on the end of the plug.

An important detail of a key is the *stop-pin f*. This pin projects from the side of the plug and engages shoulders cut on the body of the socket, thus limiting the motion of the plug to one-half turn, always stopping the plug when the key is fully closed. This pin should be strongly made, so that it cannot be broken easily. A key that has no stop-pin is dangerous, since it is quite likely to be left open a little when it is believed to be closed. Such a key, when discovered, should not be permitted to remain in use, but should immediately be repaired or replaced. The plug should be lubricated with mutton tallow, the excess of tallow being carefully removed from the passages for gas.

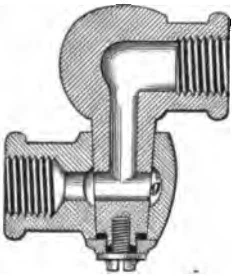

FIG. 16

The diameter of the hole *e* should never exceed one-third the diameter of the plug at that point. If the hole is made larger, the bearing surfaces are so reduced that the key is likely to become leaky in a short time.

33. Swivel-Joints. The construction of **swivel-joints** is shown in Figs. 16 and 17. The mode of securing the plugs in the sockets is the same as in Fig. 15. Each socket is provided with a groove *g*, which permits the gas to pass freely into the bore of the plug, in all positions. Fig. 16 shows an ordinary *single swivel-joint*, and Fig. 17 shows the arrangement of a *double swivel-joint* or *universal joint*. The plug *h*, Fig. 17, turns in a socket *k*, formed in the head of the plug *m*, which

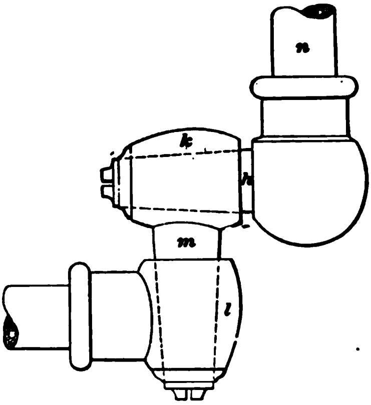

FIG. 17

revolves in the socket *l*. The pipe *n* can thus swing around the axis of either plug, or both, at the same time.

This construction is not suitable for an apparatus that requires a large supply of gas, because the dimensions become so great as to be clumsy. When the full capacity of the pipe is required to carry the desired amount of gas, the swivels may be constructed substantially as shown in Fig. 18; this is called a *full-bore swivel*. The sections *a* and *b* are fitted together with a conical joint *c*, which permits complete rotation. The joint is tightened by means of the bolt *d* and nut *e*, and if it becomes leaky at any time, it can be readily reground. The passageway for gas is equal to the full area of the pipe at all points; therefore, it offers very little obstruction to the flow.

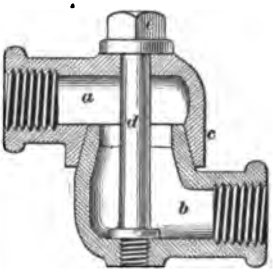

FIG. 18

34. Fig. 19 shows the construction of a **ball joint,** which permits the tube to swing to a limited extent in any direction, and also to turn on its own axis. The tube *b* is attached to a ball *c* that is confined in a socket *d* by means of a screw-cap *e*. Packing material, usually a cup leather, is employed to make the connection gas-tight from *a* to *b*. The swing of the tube is limited by the size of the hole in the cap *e*. This class of a joint is often used at the top of swinging chandeliers, *a* being the iron-pipe drop piece extending through the ceiling.

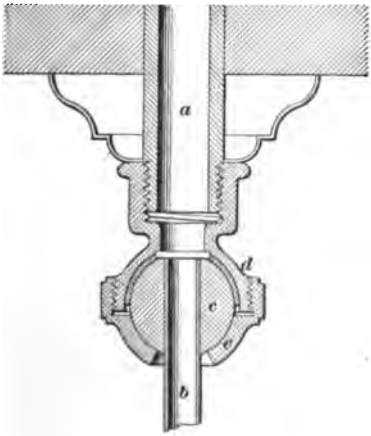

FIG. 19

35. Chandeliers.—An **extension, or telescopic, chandelier** is shown in Fig. 20. The fixture is provided with two tubes, an inner one *a*, which serves to conduct gas to the burners, and an outer one *b*, which has a cup *c* at the top end. The space between the tubes *a* and *b* is filled with a liquid, and the supply pipe *d* dips below its surface at all times, thus preventing the gas from escaping. The pendant is held up by chains *e* and weights *f*, and can be raised or lowered as desired.

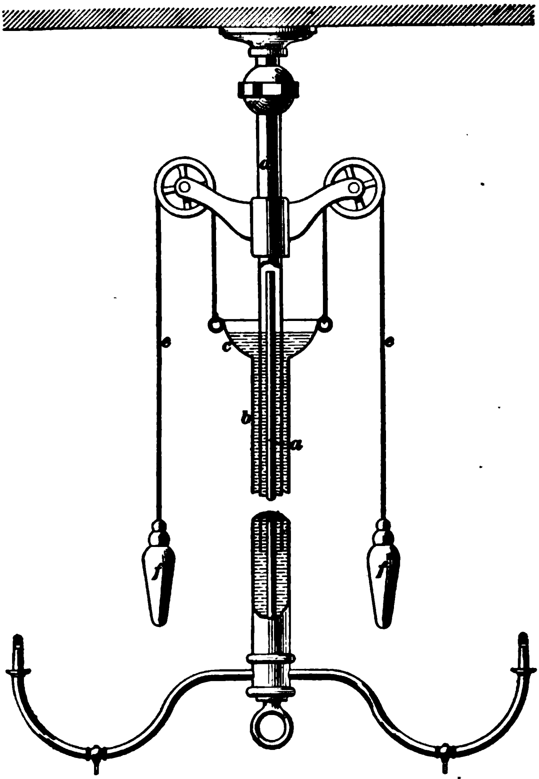

FIG. 20

The chains are provided with stops to prevent the pendant from being lowered so far that the liquid may uncover the end of the pipe *d*. Instead of the chains and weights, coiled springs (like sash balances) are frequently used to sustain the fixture. The liquid may be either oil, glycerine, or mercury; water is unsuitable because it evaporates rapidly.

36. The design illustrated in Fig. 20 was formerly much in use, but in recent years it has given place to that shown in Fig. 21. The liquid seal is replaced by a stuffingbox *g* attached to the top of the sliding tube *k*, and that slides gas-tight over the supply tube *h*. The outer tube *m* is provided with a collar *n* that guides the draw-tube *k* and prevents dust from entering the interior and settling on the surface of the tube *h*. The lubrication of the tube and stuffingbox can thus be maintained for a long time. As the tube *h* has to supply gas only, it can be made quite small in diameter. The devices used for balancing or sustaining this fixture in position are of many kinds. One of the best of these is a friction clutch that permits the draw-tube to slide upwards without resistance, but that grips it and prevents it from moving downwards, except when pulled down by force.

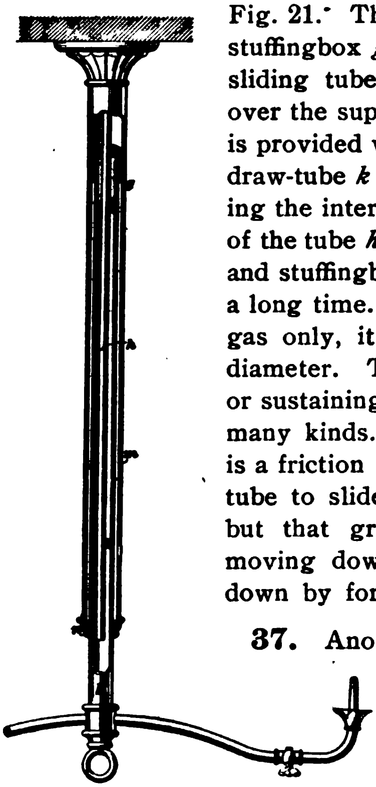

FIG. 21

37. Another design of chandelier that serves a similar purpose is provided with a small sliding tube that usually carries only one burner. All the other burners are carried on rigid arms in the ordinary manner and are not adjustable. The sliding tube, however, is usually so slender that it lacks the strength to properly support the weight of a good shade, and it is difficult to keep the stuffingbox gas-tight. The surface of the tube being somewhat oily after sliding through the packing, becomes coated with dust, and the dust soon spoils the tightness of the packing.

38. The **drop light** shown in Fig. 22 is to be preferred for ordinary uses, such as for reading or for sewing tables. It consists of a tube of suitable length having a burner and shade at its lower end and a socket or cap at its upper end; this socket is lined with rubber and is adapted to fit gas-tight over the body of an ordinary burner. The socket should always be quite close to the tube, so that it can be passed up through an ordinary globe ring or holder. The tube should be offset so that the center of gravity of the shade, etc. will come directly under the socket without tending to bend the burner to which it is attached. The tip should be removed from the burner before attaching the socket to it. Many chandeliers are provided with a small stiff bracket made especially for use on drop lights.

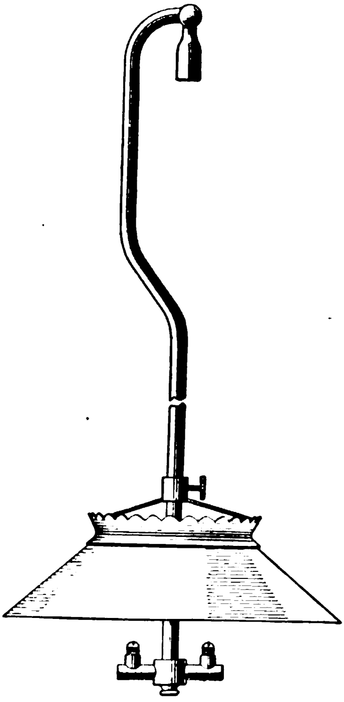

FIG. 22

39. Gas Arc Lamps.—A certain form of gas lamp, partially because it is designed as a substitute for the electric arc lamp and also because its general appearance is similar to that of the electric arc lamp used indoors, is known to the trade as a **gas arc lamp.**

The gas arc lamp, like the electric arc lamp, is used extensively for lighting large stores, halls, auditoriums, and other large rooms. It has been found to give a more steady and more satisfactory light than the electric arc. Fig. 23 shows a gas arc lamp used for indoor service. It is substantially composed of a cluster of incandescent burners *a* supplied with gas through a tube *b* suspended from the ceiling. The tube *b* is screwed into a distributing socket that feeds the arms *c* to which the burners are attached. The air and gas checks are located at the base of each burner below the gallery *d* that supports the globe *e* and shade *f*. The air supply to the globe is obtained through the gallery and lower neck of the globe; the products of combustion escape to the atmosphere through the top of a sheet-metal chimney *g*, as shown by arrows. If the top of the arc is within 4 feet of the ceiling, it is advisable to place a shield on the tube *b* that will diffuse the current of hot air and reduce its temperature before it reaches the ceiling; otherwise, a shield is seldom used.

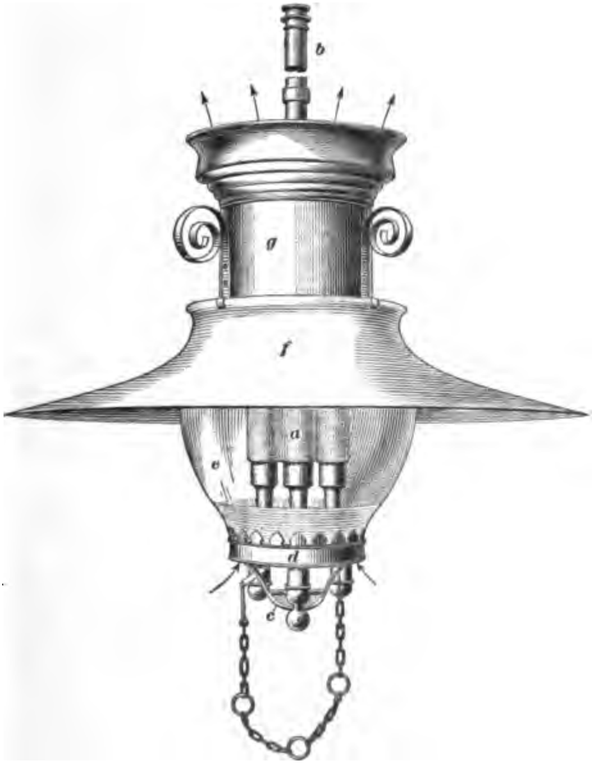

FIG. 23

40. The candlepower of gas arc lamps can be arranged to suit the requirements. Ordinarily, they are made from 400 to 600 candlepower, and are built up of four or six 100-candlepower burners, as required. A very powerful lamp can be made up of ten 120-candlepower burners, giving

1,200 candlepower in all. Fig. 23 shows a lamp that will emit about 400 candlepower, which is usually sufficient for general illumination. The lamp should be suspended at least 8 feet above the floor. The gas is turned on by pulling down the rings in accordance with printed instructions given with each lamp. In the lamp shown, all the burners are lighted simultaneously by pulling on the lower ring. By pulling on the ring at the right, which has a different color from the ring at the left, all the burners are shut off except one. By pulling the other ring the burners are all shut off.

41. Gas arcs should always be provided with a **pilot light,** which should burn night and day. Since this light consumes only about 1 cubic foot of gas in 24 hours, the cost of the pilot light need not be considered. The pilot light makes the gas arc as convenient as the electric arc, while the feature of being able to leave one burner lighted while all the rest are shut off is a decided advantage over the electric arc which can only burn at its full candlepower. To renew mantles on this form of fixture, the globe, shade, and chimney can be raised on the rod *b*; and to clean the globe, it can be lowered.

DETAILS OF GAS FIXTURES

42. Igniters.—The object of an **igniter** is to automatically ignite the gas as soon as it is turned on. This is accomplished in two ways: (1) by allowing a small quantity of gas to burn constantly inside the lamp; and (2) by producing a flame or spark that will automatically ignite the gas when it is turned on. The former is the simplest, cheapest, and most common plan. Igniters are used for lighting gas burners either singly or in groups, and are designed to save the time and labor that would be required to light them by hand.

43. A **self-lighting gas burner** is shown in Fig. 24. The key is so made that the gas can never be entirely shut off, and when it is turned to extinguish the light, a small amount of gas is still allowed to pass—enough to maintain a very small flame at the tip of the burner. In order to protect this little flame from extinction by drafts of air, it is enclosed by a cap or globe *g*. When the burner is in full operation, the globe drops below the flame to the position shown; but when the lever *b* is reversed to shut off the gas, the link *d* operates to raise the globe above the top of the burner, thus shielding the little flame from accidental extinction. The lower end *a* is a socket, threaded to fit the ordinary fixture. The fixture to which this burner is attached must be provided with a key, as usual, so that the burner may be entirely extinguished when desired.

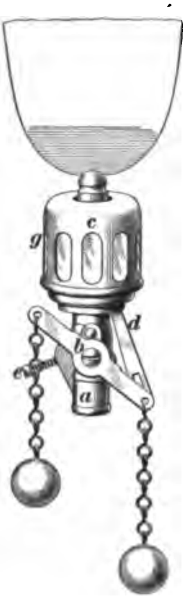

FIG. 24

Sunlights and other large groups or clusters of burners are usually lighted in a similar manner. When the cluster is extinguished, one small tip is left burning, and this serves to relight the whole group when the gas is again turned on. This small burner is supplied with gas by a separate pipe. The supply of gas to all the other burners is controlled by a single cock, so that they may be turned down simultaneously, and may be extinguished or promptly relighted whenever desired.

44. A simple by-pass gas-cock, similar to that shown in Fig. 24, may be used for incandescent lamps, the only difference being that *c*, *d*, *g*, and the burner tip are removed. The Bunsen tube of the incandescent burner, instead of the plain burner shown, is screwed on the top of the by-pass cock. When the by-pass cock is shut (the cock on the gas fixture being open), sufficient gas escapes to form a very small blue flame, or cap, on the top of the Bunsen tube, inside and at the base of the mantle. When the cock is opened, this flame is increased to the full size and the mantle at once becomes incandescent. There is a danger connected with this type of igniter, namely, that a slight draft of air against the air openings of the Bunsen tube may dilute the gas and air mixture to such an extent that the small flame, or pilot light, will be extinguished.

A yellow-flame pilot light is more positive than a blue-flame light, because it cannot be extinguished so easily. The yellow flame is obtained by a small tube that supplies the pilot light with gas taken directly from the by-pass cock or the gas space below it.

There are two general types of yellow pilot lights: one is fed by a small pipe extending up from the by-pass through the Bunsen tube and into the space within the mantle; the other is fed by a small tube *a*, Fig. 25, led up from the by-pass cock outside of the burner to a point near the mantle. A small yellow flame burns at the top of this tube constantly and immediately ignites the gas when the by-pass cock is opened. The glass globe *b* protects the pilot light from drafts. The construction of the by-pass may be such that the pilot light is extinguished only when the mantle is incandescent.

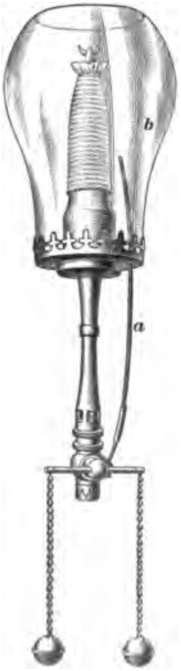

FIG. 25

45. There are numerous igniting devices that operate by means of electricity. Two methods are in use: (1) an electric spark is caused to flash through the stream of gas issuing from each burner, thus igniting it; (2) a small piece of platinum wire is heated to incandescence near the tip of each burner, the electricity being turned on after the gas issues from the burners, and shut off as soon as the lights appear. They are useful chiefly for lighting burners that are but infrequently used, as in churches; also, for burners that are exposed to the weather, as on porches, piazzas, and driveways. They are usually attached to the burners and wired by electricians.

46. Safety Burners.—A device that is designed to automatically close a valve and shut off the flow of gas from the burner when the flame is accidentally extinguished, is known as a **safety burner.** Numerous devices of this kind have been patented, but few of them will operate with sufficient certainty to be worthy of confidence. Nearly all safety burners employ bars of metal or other substances that are expanded by the heat of the flame, and while in that condition hold the gas valve open. When the flame goes out, the expanding body contracts by cooling and permits the valve to close.

One of the most simple automatic safety burners is that shown in Fig. 26. It is simply an ordinary bat's-wing or other form of a burner tip fitted with a disk *a* and a coiled platinum spring *b*. When the spring is cold, it draws *a* to its seat and shuts off the gas. When it is heated the spring expands and pushes down the valve, thus opening a passage for the flow of gas. The edge of the gas flame touches the spring and keeps it heated, but the moment the gas is extinguished, whether shut off at the gas-cock or blown out by accident or ignorance, the valve will quickly take its seat.

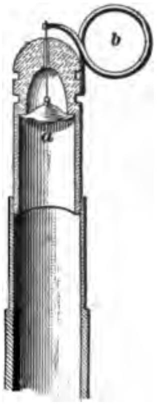

FIG. 26

Safety burners are particularly valuable where there is a liability of the gas flames being extinguished by drafts or otherwise. If the gas supply is interrupted or shut off, every burner is extinguished, but the keys are not closed. When the gas flows again into the house pipes, it streams out of each open burner, and in many instances does great damage by causing explosions or by suffocating the inmates of the building.

47. Chimneys.—Cylinders made of glass or other transparent material, such as mica, are used on gas fixtures to increase the velocity of the air moving around a gas flame, and are known as **chimneys.** They also steady the flame and are much used with Argand burners. Chimneys are used to enclose incandescent mantles, and are durable when made of good glass. In places where glass chimneys are subject to side drafts of cool air they are liable to crack because one side of the chimney becomes cooler than the other. In such cases it is advisable to use chimneys made of mica.

48. **Globes.**—The primary object of enclosing a gas burner within a **globe** is to protect the flame from interference by drafts of air. A globe, however, also acts as a chimney and causes a strong upward current of air to flow through it. If the dimensions of the globe are not suited to the size of the flame, the air-current will cause the flame to flicker badly, and the globe then becomes a detriment instead of an advantage.

The opening at the top or bottom of a globe should never be less than 4 inches in diameter for an ordinary 5-foot bat's-wing or union-jet burner, and a larger size is still better. Much smaller openings can be employed satisfactorily for incandescent burner globes.

Globes are often required to serve the purposes of shades, to modify and soften the light. For this purpose the outer surface of the glass is etched; or ground or colored glass is employed. These globes obstruct the light, the loss being about as follows: Ground glass globes, 10 to 30 per cent.; opal glass globes, 30 to 40 per cent.; colored glass globes, 40 to 60 per cent.

Globes of clear glass obstruct the light somewhat; but, if the globe is properly proportioned, the intensity of the light will be increased by the draft that it creates, and the increase of light will counterbalance the loss by obstruction. There is a great variety of globes in the market, differing chiefly in shape and ornamentation. Their selection is purely a matter of taste, and can advantageously be left to the lady of the house.

49. **Diffusion globes** are such as are constructed to diffuse the light advantageously throughout a room and reduce the apparent intensity of the flame. The class known

as the *Holophane globes* is characteristic of this type. These globes are made in many shapes, but the feature essential in all is a prismatic form of the glass, which gives the globes a corrugated appearance. The prismatic projections bend the rays of light and guide them toward the parts of the room that require the increased illumination. Fig. 27 shows a Holophane globe *a* attached to an incandescent burner. The beams of light from the incandescent mantle are bent in all directions, both by reflection and refraction, particular care being taken to bend a large number of them downwards, as shown, to illuminate the space that would otherwise be shaded by the burner and gallery.

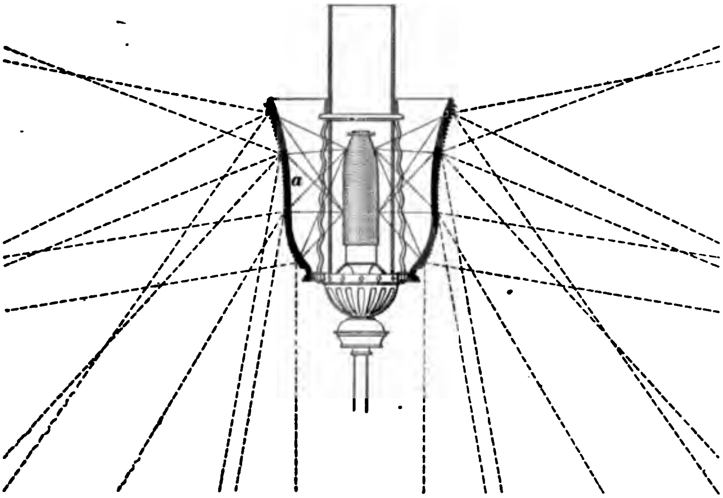

FIG. 27

A properly constructed globe of this class will diffuse the light so perfectly that the flame cannot be seen; the globe will apparently become incandescent, but not be so intense as the actual flame inside.

50. Shades.—In order to prevent the light from passing upwards, and to reflect a considerable part of it downwards, a fixture known as a **shade** is used. It is therefore desirable that the under side of the shade should have a good reflecting surface. For table and desk lights, the shades should be made of opaque material, and should act as reflectors only.

Fig. 28 shows an ordinary incandescent burner equipped with a chimney *a* and an 8-inch crimped opaque shade *b*. Sufficient light passes through the shade to prevent a dark shadow on the ceiling; a large portion of the light is reflected downwards, however, and prevents a shadow being cast by the burner.

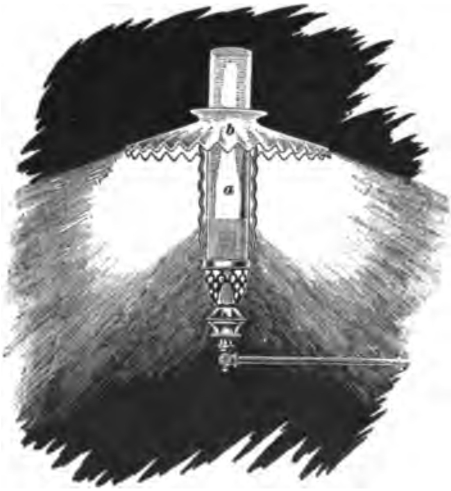

FIG. 28

The color of globes and shades is a matter of some importance. If translucent shades are used, they should be either white or opal. Red, green, and blue shades should not be used, because of the bad effect of the colored light on the eyes; red light, especially, is very tiresome to sensitive persons.

The central opening in the top of the ordinary shades permits a considerable portion of the light to pass upwards to the ceiling. When it is desired to prevent this, top reflectors, as shown at *a*, Fig. 14, may be used to intercept the light and throw it downwards.

51. Shields.—The distance between an ordinary gas burner and the ceiling should be not less than 3 feet. If a less distance is unavoidable, the ceiling should be protected by a **metal shield** to prevent its being scorched or burned. The shield should be separated from the ceiling by a clear space of at least 2 inches, to permit air to circulate between it and the ceiling. Even when a shield is provided, a gas flame should not be permitted at a distance less than 18 inches below the ceiling.

If a gas flame is liable to come into accidental contact with inflammable materials, such as curtains or drapery blown by the wind, or hay and straw in stables, etc., it should be provided with a glass globe, and should also be enclosed within a stout wire cage at least 10 inches in diameter. The only safe way to determine the proper size of the wire guard is to test it by holding pieces of cloth or paper against it. If the material can be set on fire, the guard should be made larger.

LOCATING GAS FIXTURES

52. The chief considerations that govern the location of gas fixtures are: (1) that they shall light the rooms to the best advantage, and (2) that they shall cause no danger from fire.

In lighting bedrooms, the fixtures should be located so that the bed, wardrobe, dressing case, mirror, etc. may be placed in desirable positions without interfering with the light. The positions of the closets should be noted, and, if practicable, the light should be arranged to shine into them, so that the contents may be easily seen.

Dressing mirrors should be provided with two stiff bracket lights, one at each side. They should be placed as high as they can conveniently be reached, in order to properly illuminate the head and shoulders of the person using the mirror.

In bathrooms, the lights should be set high, so that a person will not be liable to strike them in taking off or putting on clothing. A light should not be located over a bathtub or a wash bowl, or anywhere near them, because of the liability to accident.

Stairways should be provided with a light at the top, whether there is one at the bottom or not. A light on the newel post alone is not sufficient to properly illuminate the steps. People having defective sight are especially liable to accident on stairways, and the light should be arranged so as to avoid all shadows that might prove deceptive.

A kitchen or laundry should be lighted by pendants whenever practicable. If side lights must be used, they should not be placed over the sink or near enough to it to be liable to be struck, or be splashed with water. A side light should not be placed over a set of tubs if it can be avoided. The stairway leading from the kitchen to the basement or cellar should be lighted by a burner that is located some distance away from the foot of the stairs. If the light is near the foot of the stairs, it is very apt to be struck when large articles are carried past it.

Hallways are best lighted by a pendant; if a side light is used, it should be placed where it will not interfere with the coat rack, mirror, or other hall furniture. A pendant in a hallway or vestibule should be set so high that the globes will not be liable to be knocked off by a person who is putting on an overcoat, etc.

Chandeliers should be hung from the center of the ceiling, as nearly as practicable. If several side lights are used in the same room, they should be placed at the same height.

Swing brackets should not be used for lighting hallways, stairs, vestibules, or other passageways, because of the danger from fire. The light is very liable to be swung too close to the wall, and to be overlooked until the building is set on fire. Swing brackets are always a source of danger when they are located within reach of woodwork or drapery, and therefore are not to be recommended for general use. It is preferable, in most cases, to use instead two single lights on stiff brackets, or else a bracket having two or more rigid arms with fixed lights.

A gas fixture should never be placed in a closet or other very small room, if there is any chance that the door may be closed and the light left burning. If that should happen, the temperature would rise rapidly, and there would be great danger of setting fire to any combustible material that might be in the room.

Care should be taken in locating side lights to make sure that wooden doors cannot be swung back against them, and be scorched or set on fire. Lights should not be placed where they may be blown out by strong drafts of air, or by the sudden slamming of a door. A gas burner when extinguished with a full head of gas on is very dangerous.

Hot-air registers in the floor or wall should be carefully avoided in locating gas fixtures. If a light is over or near a register, it will flicker incessantly, and will be a great annoyance.

The proper height of gaslights above the floor depends somewhat on circumstances. In ordinary dwellings having a ceiling 9 feet high or more, side lights should be placed from 5½ to 6 feet high. Pendants may be hung from 6½ to 7 feet from the floor. If the rooms are large and high, the lights of chandeliers may be placed at a height of from 7 to 8 feet, or even more. Of course, all lights above 7 feet high will require the assistance of a torch or step ladder to light them.

Side lights in hallways and vestibules of churches and similar buildings should be placed at a height of at least 7 feet.

Low lights should be avoided, because they are tiresome to the eyes. If they must be used, they should be provided with opaque shades.

LIGHT

PROPERTIES OF LIGHT

53. Light diminishes in intensity as it recedes from the luminous body, the law governing the diminution being: *the intensity varies inversely as the square of the distance from the source of light.*

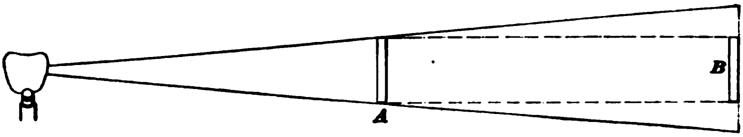

Fig. 29

Thus, if the two equal surfaces *A* and *B*, Fig. 29, be illuminated by the same lamp, *A* being 2 feet away from it and *B* 4 feet, then *B* will receive less light than *A*, in inverse proportion to the squares of their relative distances, or in the proportion of $\frac{2^2}{4^2} = \frac{4}{16} = \frac{1}{4}$.

That this law must be true is evident from an inspection of the figure. The light that is intercepted by *A*, if permitted to proceed, will illuminate an area at *B* that is twice as high and twice as wide as *A*. The same amount of light is thus spread over four times the area of surface, and consequently it can have but one-fourth the brilliancy.

54. Light proceeds from a luminous body equally in all directions. It always moves in straight lines unless the medium through which it passes varies in density. Thus, if it passes through a body of air that is warmer in one part than in another it will be deflected, and the object viewed will appear out of its true position.

55. When light falls obliquely on a plate of glass, its direction is changed within the interior of the glass; this change of direction is called **refraction.** When the light emerges from the opposite surface of the glass, its direction is again changed. If the surfaces are parallel, the light will resume its former direction, as shown at *A*, Fig. 30; but, if they are not parallel, the ray will be permanently deflected from its course, as shown at *B* in the same figure. On entering the glass, the ray of light *a* will be bent or refracted to the line *d*, thus making a larger angle with the surface of the glass than the original ray. When it leaves the glass, it will be again bent, but to a smaller angle with the surface

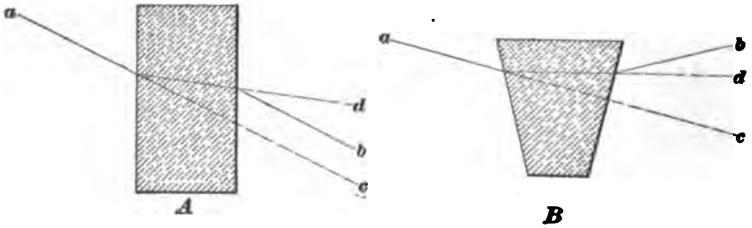

FIG. 30

from which it emerges. If an object at the point *c*, in either case, be looked at from the point *a*, it will appear to be located at *b*.

The refractive powers of glass, ice, crystals, water, oil, and gas differ greatly. Any of these substances may be employed, in the form of lenses, to concentrate or disperse light. A certain kind of crystal called *Iceland spar* refracts light twice simultaneously, causing objects seen through it to appear double.

56. Light that is scattered in many directions is said to be **dispersed.** Thus, light is dispersed by reflecting it from a roughened or corrugated surface, or by transmitting it through a shade or screen of glass having a frosted or corrugated surface. Light that is transmitted through white or opal glass is not dispersed, but is merely reduced in intensity. Usually, however, the surfaces of such shades are corrugated, and more or less dispersion is produced thereby. One of the best materials for dispersing light is frosted or ground glass.

57. When light falls on a mirror, part of it will be turned back or turned aside from its original path. This change of direction is called **reflection.** The proportion of light that will be reflected varies with different materials, with the condition of the reflecting surface, and with the angle at which the light strikes the reflector.

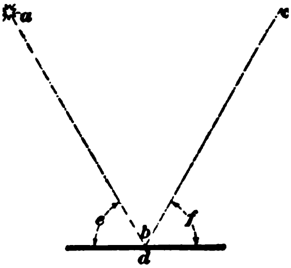

FIG. 31

The ray of light that proceeds from the source of light to the mirror, as *a b*, Fig. 31, is called the *incident ray*, and the ray that is reflected, as *b c*, is called the *reflected ray*.

The law that governs the direction of the reflected ray is as follows: *The angle made by the reflected ray with the surface of the mirror will always equal that made by the incident ray;* that is, the angle *f* always equals the angle *e*. If the mirror is curved, as in Fig. 32, the angles are measured to the line *h i*, which is a true tangent to the curve at the point *b*, where the ray strikes the mirror.

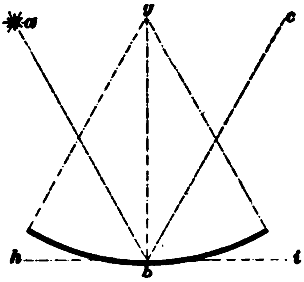

FIG. 32

58. Reflectors should be made of brightly polished metal, or of silvered glass attached to a metal frame or backing. The silvered glass will not endure much heat; consequently, the polished metal should be used if the heat from the burners is likely to be excessive.

The most effective reflectors are those having the outline of a parabola, with the flame at the focus. All the rays that are received on the reflector are then reflected in parallel lines, as shown in Fig. 33. The angles formed by the dotted lines *a 1*, *a 2*, *a 3*, etc. are all equal; consequently, the volumes of light reflected through the spaces enclosed by the dotted parallel lines are also equal.

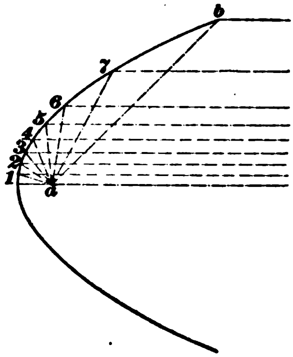

FIG. 33

Fig. 34 shows a parabolic reflector designed for a sunlight. It is made in halves that are separated a distance equal to that between the centers of the gas flames *a* and *b*.

Large and expensive reflectors are often erected with very unsatisfactory results. The trouble usually arises from the fact that no effort was made to adapt the shape of the reflector so as to produce the effect desired.

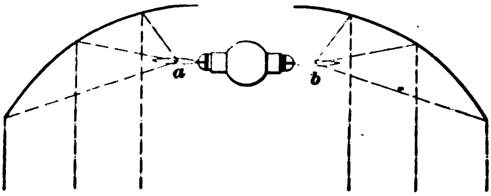

FIG. 34

ARTIFICIAL ILLUMINATION

59. General Considerations.—The ideal condition in artificial illumination is to have the light coming from overhead, and to have it so thoroughly diffused that no object in the room shall appear conspicuously brighter than any other. While it is impracticable to attain this ideal condition with the means at hand at the present time, yet this principle should be kept always in mind so that mistakes in lighting may be avoided.

Lights of great brilliancy, such as electric arc lights, not only dazzle the eye but frequently produce blindness. Oculists strongly condemn these lights, because they impair the vision of persons using them. The trouble is due mainly to the brilliancy of the light. In using artificial lights for illumination, the aim should be to illuminate all objects within the ordinary field of vision to about the same degree of brilliancy as that afforded by diffused daylight. Objects that are lit up by direct sunlight are usually too bright to look at continuously.

The flames of gas burners or lamps are much too bright to be looked at directly; therefore, they should be screened, so that whatever light reaches the eye shall be reduced to a moderate intensity.

The physiological effect of a light that shines in the eyes of a person that is looking at something else, is to produce considerable nervous irritation and fatigue, if long continued. Thus, if a gas burner or kerosene lamp, or any bright object, comes within the ordinary field of vision while a person is listening to an address, and is looking toward the speaker, it will cause a great deal of uneasiness. A few lights thus misplaced will fatigue an audience to a greater degree than is generally supposed. Therefore, all lights located in the vicinity of a person addressing an audience, either above or behind, or at either side, should be fully covered by opaque screens that will prevent any light from passing toward the audience. While the irritating brilliancy of such lights may be mitigated by means of globes of white or opal glass, they continue to be conspicuously bright and are very objectionable. The best result is obtained by using opaque screens that reflect the light back on the platform. For similar reasons, all chandeliers or pendants should be hung so high that the lights will not come within the field of vision of any person looking toward the platform or speaker.

Large audience rooms, such as churches and lecture rooms, can be illuminated to best advantage by means of groups of small burners located near the ceiling and provided with proper reflectors to project the light downwards. These sunlights may be arranged in various forms and can be adapted for almost any kind of service. Their light is more agreeable than that from a single burner of equal power, because it proceeds from a large number of flames and is thus so diffused that the shadows are very soft or indistinct.

This method of lighting is correct in principle, and it should be employed for domestic lighting to a much greater extent than at present. While there are some difficulties in carrying out the plan on a small scale, yet these should act as a stimulus to invention rather than as a bar to improvement. The introduction of the modern high-power lamps, such as the Wenham regenerative and the Welsbach incandescent lamp, makes it necessary that great improvements be made in the methods of distributing and diffusing light. There is great need of such improvements for domestic illumination.

Flat gas flames, when turned horizontally, give a brighter illumination to objects below them than when burning in the ordinary erect position. The gas flames in overhead sunlights should always be horizontal.

60. Amount of Light Required.—Rooms having dark-colored walls, or having much colored drapery, will require more light than they would if finished in white. The white walls reflect and disperse the light, thus aiding the general illumination, while colored walls reflect less in proportion to the brightness of their coloring.

61. The rule commonly used for computing the number of ordinary 5-foot bat's-wing burners that will be required to properly illuminate a church or other large room is as follows:

Rule.—*Divide the area of the floor of the room, in square feet, by 40; the quotient will be the number of burners required.*

Or, $$N = \frac{A}{40}$$

where N = number of burners;
A = floor area, in square feet.

If there are balconies, etc., extra lights must be provided for them by the same rule. The divisor given may be varied from 40 to 80 to suit the smaller rooms found in ordinary dwellings. The reflection from the walls is proportionally greater in small rooms; therefore, a smaller number of burners is required in proportion to the actual floor space. One 5-foot burner is assumed to give a light of 16 candlepower. The amount of light required is therefore from 16 candlepower to a floor space of 40 square feet in large rooms, to 80 candlepower in small ones, or from .4 to .2 candlepower per square foot of floor space.

Example.—How many 5-foot bat's-wing burners will be required to properly illuminate a church having an auditorium 70 feet by 100 feet, and a balcony having 2,000 square feet floor area?

Solution.—Applying the rule, $N = \frac{70 \times 100}{40} = 175$ burners for the main floor, and $N = \frac{2,000}{40} = 50$ burners for the balcony; hence, $175 + 50 = 225$ burners will be required. Ans.

62. To find the number of ordinary incandescent burners required to illuminate a certain room the following rule may be applied:

Rule.—*Divide the area of the floor of the room, in square feet, by 160; the quotient will be the number of burners required.*

Or, $$N = \frac{A}{160}$$

where N = number of incandescent burners;
A = floor area, in square feet.

The foregoing rule refers to the use of high-grade mantles that will give a light equal to at least 60 candlepower.

EXAMPLE.—How many incandescent burners will be required for a store 20 feet wide and 60 feet long?

SOLUTION.—By the rule just given,

$$N = \frac{20 \times 60}{160} = 7\frac{1}{2} = 8. \quad \text{Ans.}$$

MEASUREMENT OF LIGHT

63. Definitions.—Light can be measured only by its illuminating effects. As it cannot be absorbed and stored, as may be done with heat, quantitative measurements are impossible. The capacity of the human eye for the perception of light is comparatively small. It is unable to perceive very faint lights, and it is dazzled and confused by lights of great brilliancy. Photographic plates are affected by faint lights that are invisible to the eye; thus, photographs of the sky reveal a multitude of stars that are not visible even with the aid of the strongest telescopes. The unaided eye is unable to judge of the relative intensity of various lights with any reasonable approach to accuracy.

The art of measuring the comparative intensity of lights is called **photometry.** There are several methods of making these measurements—chemical, electrical, and mechanical—each of which is peculiarly suited to special cases. The method employed for general purposes is to compare the illuminating power of the light under examination with that of a light of standard intensity.

The unit used for all ordinary measurements is the light given by a sperm candle burning at the rate of 120 grains per hour. The candle is burned in still air, and care is taken to avoid all drafts that might accelerate the combustion and thus vary the brilliancy of the light. The light thus obtained is made the unit for comparison, and is called **1 candlepower.**

A larger unit is sometimes used for measuring very large lights. This is the flame of a certain kind of oil lamp called the Carcel lamp, and the unit thus derived is called **1 Carcel.**

64. Instruments.—All instruments that serve to measure the comparative brilliancy of lights are properly called **photometers**, but only those that are suitable for measuring ordinary gaslights, etc. will be described here.

One of the oldest of these instruments, called the *Rumford photometer*, is shown in Fig. 35. It consists of a table having a black wooden post *c*, standing erect as shown, and a screen *g*, which receives the shadows of the post that are cast by the lights *a* and *b*. The candle *a* is the standard light, and *b* is the light whose intensity is to be measured.

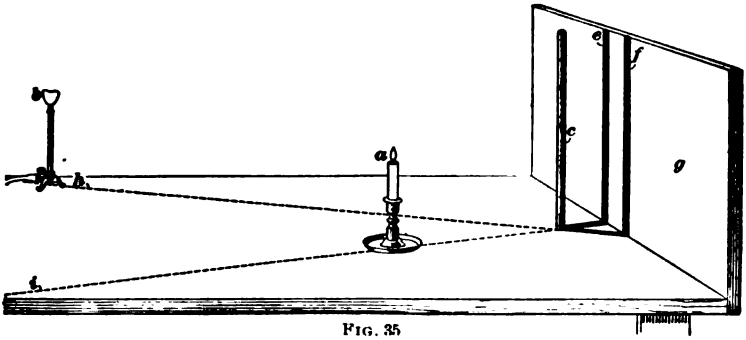

FIG. 35

The lines *h c* and *i c* must be at exactly equal angles with the screen, and the lights are moved back and forth along these lines until the shadows *e* and *f* appear of exactly equal blackness. The powers of the two lights are then computed by dividing the square of the distance *b c* by the square of the distance *a c*, the quotient being the candlepower of the light *b*.

This method is very inaccurate, and is not to be recommended, because the eye is unable to compare the shadows *e* and *f* with the requisite accuracy.

65. The *Bunsen photometer*, shown in Fig. 36, operates on a different principle than the Rumford. A diaphragm *c* is illuminated on its opposite sides by the light *b* and the standard candle *a*. The observer looks down through the tube *e* into mirrors *f* and *g*, and thus sees the reflection of both sides of the diaphragm at the same time. If they appear of unequal brilliancy, the sight-box *d* is moved along the bar *h* until they become equal. The candlepower of the light *b* is then found by dividing the square of the distance *b c* by the square of the distance *a c*; usually the bar is graduated, as shown, so that no calculation is necessary.

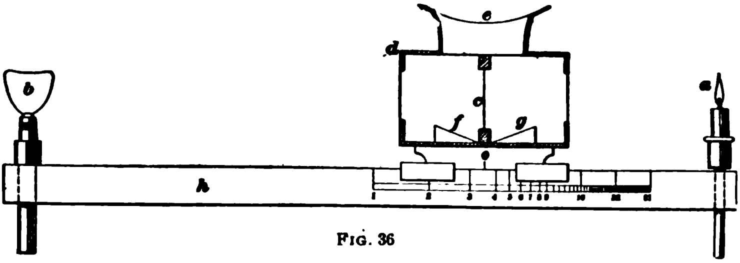

FIG. 36

66. The two constructions of the diaphragm are called the spot diaphragm and the star diaphragm. The *spot diaphragm* is shown in Fig. 37. The center *a* is a disk of opaque white paper. The ring *b* is made of white paper saturated with paraffin and is translucent. The outer part *c* is blackened. When this diaphragm is unequally illuminated on its opposite sides, the ring *b* looks darker, or brighter, than the center *a*, but when the illumination is exactly equal, all difference disappears and the spot *a* becomes indistinguishable.

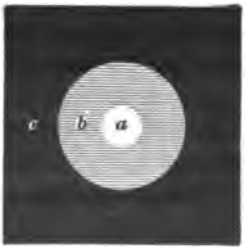

FIG. 37

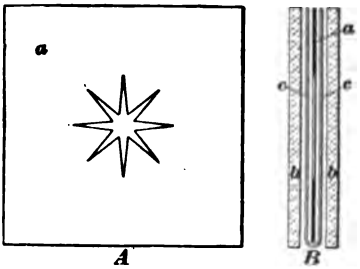

FIG. 38

The *star diaphragm* is shown in elevation at *A*, and in section at *B*, Fig. 38. It consists of a piece of white writing paper *a* of moderate thickness, having a star-shaped figure cut out of its center, and a sheet of thin white writing paper *c*, of best quality, which is doubled so as to enclose the piece *a*. The diaphragm is lightly squeezed between two pieces of glass *b, b*. Care is taken in cutting the star to make every point and line clear and sharp. When the reflection of the diaphragm is seen in the mirrors, the images will vary in distinctness if the lights are unequal. The sight-box *d* in Fig. 36 is then moved along the bar until both images of the star appear equally sharp and clear.

67. It will be observed that the methods of testing employed in the photometers described are quite different. In the Rumford method, the observer judges the equality in blackness of the shadows produced; in the Bunsen method, using the spot diaphragm, he judges by the equal brightness of the opposite sides of the diaphragm, and when using the star diaphragm, he judges by the equal clearness and distinctness of the two images of the star. The Rumford method has been discarded for the more accurate Bunsen method. Both the spot and the star diaphragms are widely used, but the star diaphragm is preferred because of its superior accuracy.

TABLE II

GRADUATIONS OF BUNSEN PHOTOMETER BAR

C. P.	x	C. P.	x	C. P.	x	C. P.	x
1	50.00	11	23.17	21	17.91	31	15.22
2	41.42	12	22.40	22	17.57	32	15.02
3	36.61	13	21.71	23	17.25	33	14.83
4	33.33	14	21.09	24	16.95	34	14.64
5	30.60	15	20.52	25	16.67	35	14.45
6	28.98	16	20.00	26	16.40	36	14.28
7	27.43	17	19.52	27	16.14	37	14.12
8	26.12	18	19.07	28	15.90	38	13.96
9	25.00	19	18.66	29	15.66	39	13.80
10	24.04	20	18.27	30	15.43	40	13.65

68. In practice, the distance between the centers of the lights is usually made 100 inches for a Bunsen photometer. The bar is graduated in accordance with Table II, where the abbreviation C. P. means candlepower, and x the distance, in inches, between the standard candle and the disk of the sight-box.

69. The distance x in Table II, equal to ac in Fig. 36, may be computed for any distance between the centers of the lights and for any candlepower by the following rule:

Rule.—*Divide the distance between the centers of the lights, in inches, by the sum of 1 and the square root of the candlepower.*

Or,

$$x = \frac{d}{1 + \sqrt{c}}$$

where d = distance between centers of the lights;
c = candlepower.

EXAMPLE.—If the distance between the flames of the light to be tested and of the standard candle is 150 inches, what should be the distance between the diaphragm and the standard candle for 64 candlepower?

SOLUTION.—Applying the rule just given,

$$\text{distance} = \frac{150}{1 + \sqrt{64}} = 16.67 \text{ in.} \quad \text{Ans.}$$

70. In testing high-power lights at the standard distance of 100 inches, such as incandescent gaslights, it is advisable to use two or more standard candles instead of one. The candlepower readings corresponding to the graduations, as given in Table II, must then be multiplied by the number of standard candles used to get the candlepower of the flame being tested.

71. Any good mechanic can construct a photometer like that shown in Fig. 36, which will be sufficiently accurate for all ordinary purposes. By its aid he can investigate for himself, and can acquire much valuable information. In using the photometer, care must be taken to prevent the entrance of light into the sight-box from any other source than the lights that are to be compared. A screen of black velvet should be suspended behind each light to prevent any light from being reflected toward the sight-box. It is advisable to have a dark room to operate in even if the instrument is protected with curtains and screens of black cloth.

In testing gas, the pressure must be kept uniform, and the rate of combustion should be carefully measured.

72. The candlepower of ordinary illuminating gas is measured while burning at the rate of 5 cubic feet per hour, under a pressure of .5 inch of water column. To secure very exact measurements, small corrections must be made for the temperature of the gas and for the moisture contained in it. The candle should always be weighed before and after each test, and allowances must be made in computing the candlepower of the light under examination, if the rate of consumption of the candle varies either way from the standard rate of 120 grains per hour.

EXAMPLES FOR PRACTICE

1. How many 5-foot bat's-wing burners should be placed in a parlor measuring 14 feet by 20 feet? Ans. 7

2. How many incandescent burners are required for a hall measuring 60 feet by 80 feet? Ans. 30

3. Suppose that the standard candle and the light to be tested are 120 inches apart, how far should the diaphragm be from the standard candle for 16 candlepower? Ans. 24 in.

DOMESTIC USES OF GAS

(PART 2)

GAS HEATING

BURNER CONSTRUCTION

BUNSEN BURNERS

1. **Portable Bunsen Burner.**—All burners that are designed to produce heat rather than light, are constructed to mingle the gas with air before burning. They, therefore, belong to the class known as *atmospheric burners*. The most commonly used design of atmospheric burner is named a **Bunsen burner,** after the name of its inventor. A portable Bunsen burner is shown in Fig. 1. It consists of a gas tube *a* that projects part way into a larger tube *b*, which is called the mixing tube, or mixing chamber. Air is admitted through holes *c*, which can be partly or entirely closed by means of the collar or slide *d* to regulate the amount of air admitted. The gas issuing from *a* and the streams of air from the holes *c* mingle in the upper part of the tube *b* and form a mixture that will burn over the mouth of the tube. The flame will be quite large and unsteady, and if illuminating gas is burned, it will show a pale blue color with a tendency to green. If the proportion of air admitted through the holes *c* is too large, the flame will flash back with a sharp puff or explosion, and will then burn at the orifice of *a* with

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an ordinary yellow smoky flame. To prevent this, the slide *d* must be adjusted so as to restrict the supply of air to just below the explosion limit. If the air supply is much too large, the explosion may be sufficiently violent to extinguish the flame.

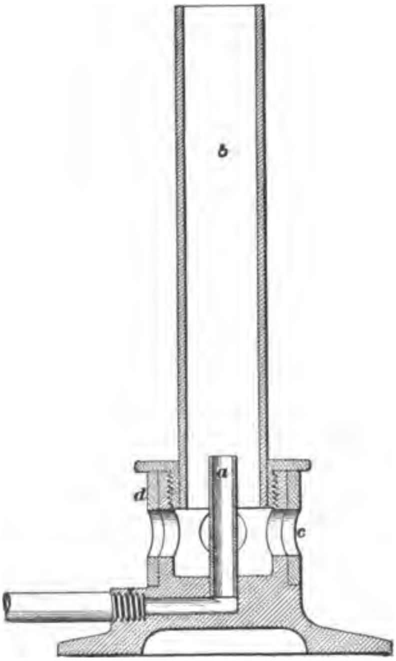

FIG. 1

2. It is necessary that the gas and air be thoroughly mixed before they reach the orifice or orifices where the mixture is burned. The mixing operation requires a sensible amount of time; therefore, the mixing chamber must be large enough to afford the gas ample time to mingle with the air properly while passing from the supply pipe to the orifices of the burner.

The air inlet should always be at the lowest part of the mixing tube or burner, so that none of the gas may escape backwards through it. Good service can be got from a burner by regulating both the air and gas supply at the same time. For this purpose compound cocks are made that control both inlets simultaneously.

3. Ring Burner.—The general design of the type of Bunsen burner commonly employed for cooking stoves is shown in Fig. 2. From its formation the name of **ring burner** is applied to it. The gas and air are mixed within the tube *a*, and the mixture is burned by means of a large number of small flames that issue from the perforations in the ring *b*. When the burner is to be used for both large and small work, it should be provided with some means of regulating the air supply, so that the mixture of air and gas may always be in the best proportion for economy. In the figure, the air inlet is at *d*; the size of the opening is then controlled by a slip collar on *a*, similar to the collar *d* shown in Fig. 1. In many cases the air-inlet openings are in the conical part of *c*, Fig. 2, the size of opening being controlled by a perforated sheet-metal cone that can be locked in position by a setscrew.

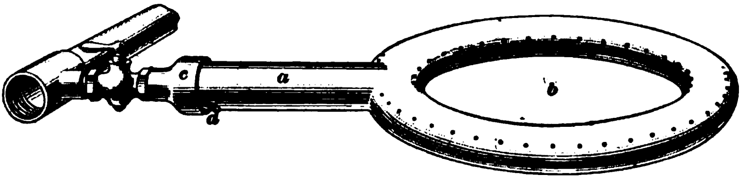

FIG. 2

Ring burners are frequently made with two or more rings of jets, the rings being concentric and in the same plane. A two-ring burner is called a *double burner;* a three-ring burner a *triple burner*, etc. Each ring should have its own mixing tube and gas-cock, so that one or all of them may be used as desired.

The amount of gas consumed by a burner varies with the size; usually it is between 10 and 18 cubic feet per hour.

4. Inverted Burners.—For some purposes burners are made to work in an inverted position; that is, with the flame on the under side. They are thus enabled to radiate heat over the top surface of materials exposed below them. This feature is of great value in cooking operations and for certain manufacturing purposes. Of course, the air inlet must then be at a lower level than the bottom of the burner.

5. Slit Burner.—There are many different shapes of burners on the market, but the principle of combustion is the same in all; their chief difference is found in their adaptability to the different makes of stoves. Generally speaking, those that are least liable to foul with grease or lampblack, or that can be most easily cleaned by the cook or other operator, are the best. Ease of cleaning is a prominent feature of the so-called **slit burners**; they differ from those having small circular perforations only in that they have slits at which the mixture is burned, the slits being large enough to be easily cleaned with a thin knife blade.

6. **Perfection Burner.**—The burner shown in Fig. 3 has the jets arranged in the form of a star, whence this type derives the name of **star burners.** The design illustrated is known to the trade as the Perfection burner. The perforations are in the arms, as *a*, of the star; the gas-supply pipe is connected at *b*. The valve *c* is used to turn on or shut off the gas supply to the burner. A setscrew needle valve *d* forms a gas check, which, when adjusted to suit the gas pressure and the requirements of the burner, prevents the operator from having too large a flame, even when *c* is opened fully. A shutter *e* can be revolved until it screws up tightly against the funnel-mouthed inlet of the mixing tube, when the air supply will be entirely shut off; it may be adjusted so that the exact air supply required will be admitted, when it is secured in position by a locknut. The principal feature of this burner is the cleaning attachment. It is composed of a lever *f* and a star-shaped cleaner *g* provided with a number of small rods or prongs projecting upwards. They are located in such a position that when the long arm of the lever is pressed down, the prongs are pushed up through the burner holes, as shown, and the burner holes are thus cleared of lampblack or other obstructions. When the pressure is removed from the lever the weight of *g* will hold the prongs down inside the burner and gas can freely flow through it.

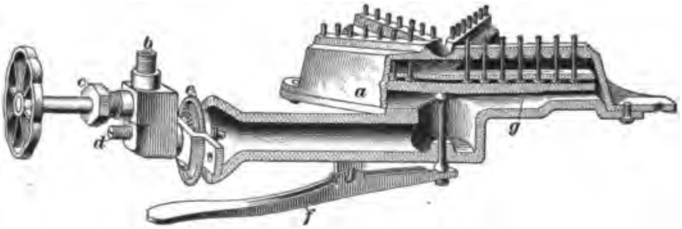

FIG. 3

7. Simmering Burner.—The ordinary large ring burner gives too much heat for the method of cooking known as *simmering*, and hence a small single-flame Bunsen jet or a very small ring burner, as *a*, Fig. 4, is supplied for this purpose to gas cooking stoves and is placed within an ordinary-sized ring or star burner. The gas supply to the simmering burner is controlled by the cock *b*. The illustration shows common practice not only in locating several burners on a gas stove, but also in the location of the mixing chambers *c*, *c*. The gas header or branch pipe *d* is usually located in front of the cooking stove. Double burners are located at *e*, *e*, and single burners at *f*, *f*. A simmering burner is placed in every good gas stove, partly for convenience and partly as a means of saving gas, as a simmering burner usually consumes only from 2 to 5 cubic feet of gas per hour.

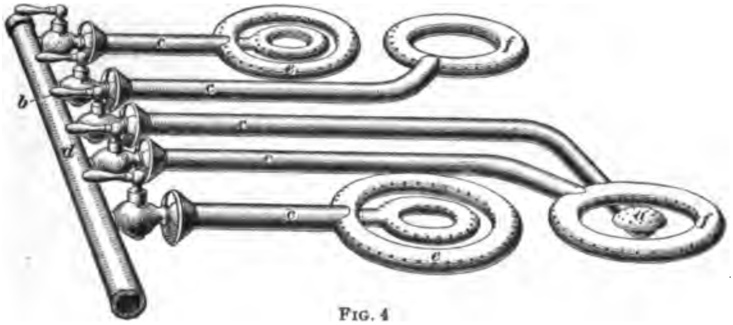

FIG. 4

8. Oven Burner.—For the purpose of heating the ovens of gas ranges many different forms of burners are used. The best oven burners are those that distribute the heat uniformly. Oven burners are located beneath the ovens, and should be capable of being lighted from the outside by means of an igniter. Fig. 5 (*a*) shows how an igniter *a* may be attached for two oven burners *b*, *b*. It is simply a tube leading from the igniter cock *c* to the burner holes. The tube is split on both sides, as shown in detail in Fig. 5 (*b*), the openings *d* extending uninterrupted from *c* to the burners. To ignite the burners, therefore, the cock is turned on full while a light is held close to the slot at the point *e* outside of the oven, when a flame will travel along the slots and reach the burners. The burner cocks *f*, *f* are now opened and the burners become ignited; the cock *c* is then closed. The igniter is not an atmospheric burner and therefore burns with a yellow flame. This makes the igniter more certain and more safe than one that burns on the Bunsen principle.

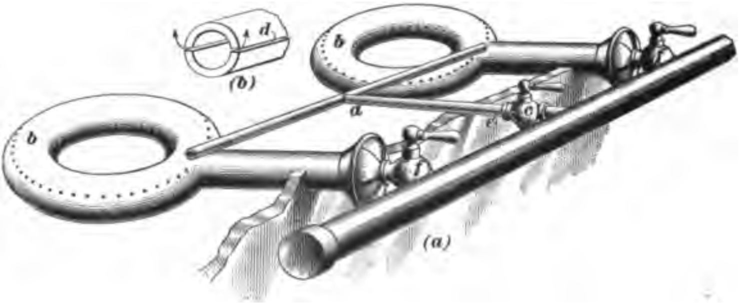

Fig. 5

9. Vaporizing Burner.—Devices for generating gas from oil by means of heat, and combined with atmospheric burners proportioned to properly burn the gas thus produced, are called **vaporizing burners.** They are commonly used with gasoline, but other and heavier oils may be used by modifying the vaporizer and burner to suit. Oil vapors have such an abundance of carbon that the quantity of air required to burn them properly is much greater than that required with ordinary illuminating gas.

The liquid is vaporized only as fast as it is used, and the heat required for vaporization is taken from the flame; usually some of the waste heat is thus utilized. The general method of construction is to have the oil reservoir elevated above the burner, so that the liquid will flow down to the vaporizer by gravity. The gas produced may be burned in any properly proportioned atmospheric burner.

10. Care of Atmospheric Burners.—The atmospheric burners used in cooking stoves, etc. seldom give any trouble if they are properly proportioned and adjusted. If the mixing tube is too small, the supply of air is apt to be insufficient, and to be imperfectly mixed with gas, thus causing the burner to smoke. The burners frequently become foul, and sometimes become clogged with burnt grease, etc. Each hole or jet should then be cleaned by inserting a wire, and the mixing tube should be inspected and cleared of all lint and dirt.

The trouble with gas grates, gas logs, and similar gas heaters is that they will sometimes blow and *snap out* or extinguish the flame, when the pressure in the supply pipe becomes unusually low. The reason for this is the air supply remains nearly unchanged, while the gas supply diminishes; thus the relative proportions are altered until the mixture becomes explosive. This trouble may be remedied by adjusting the burner and air inlet to work properly at a certain minimum pressure, which is assumed to be the lowest that will occur, and using a pressure reducer or governor to maintain the supply of gas to the heater at that pressure.

FLETCHER BURNERS

11. The **Fletcher,** or **solid flame, burner,** is shown in Fig. 6. That part of the apparatus that serves to mix the gas and air is similar in principle to that used in the Bunsen burner, but the method of burning the mixture is quite different. The top of the chamber *a* is covered with stout wire gauze *b*, and the gas burns as it issues through the meshes of the gauze. As the gas is already provided with nearly or quite all of the oxygen that it requires for combustion, it burns close to the gauze with a small compact flame of great intensity. The color of the flame, when using

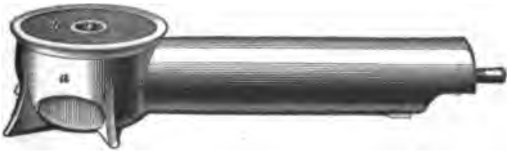

FIG. 6

ordinary illuminating gas, is a bright green with a few traces of blue. If a larger and more diffused flame is desired, it can be obtained by diminishing the air supply. The flame then spreads out in order to secure from the atmosphere the oxygen that is lacking, and it becomes less intense, appearing more like the flame from a Bunsen burner. When the large flame is used, the central air tube *c*, which passes entirely through the chamber *a*, supplies air to the middle of the flame.

The Fletcher burner is able to develop a higher heat from the gas than the Bunsen burner, because it permits a larger proportion of air to be mixed with the gas. If an attempt is made to burn, in a Bunsen burner, a mixture having the full proportion of air necessary for combustion, the flame will blow back. The same mixture will, however, burn perfectly in a Fletcher burner, because the flame is prevented from blowing back by the wire gauze *b*. Usually one or more partitions of wire gauze are provided in the interior of the burner, to act as fire-checks in case the main gauze should become broken.

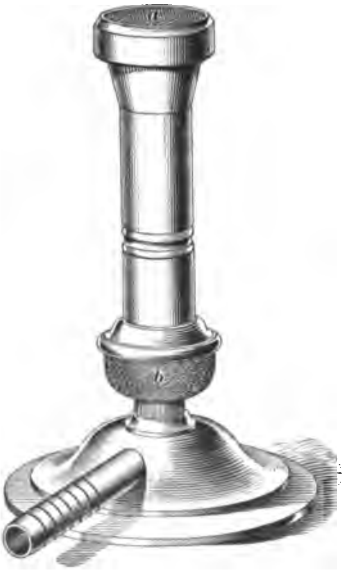

FIG. 7

12. The Bunsen burner may be transformed into a Fletcher burner to great advantage by providing it with gauze, as shown at *a* and *b*, Fig. 7. With this arrangement the flame can be turned down exceedingly low without danger of blowing back or snapping out.

FIRE-CHECKS

13. In burning explosive mixtures of air and gas, it is necessary to employ some device, called a **fire-check,** for the purpose of confining the flame to a certain place, and thus prevent it from spreading backwards into the mixing chamber or reservoir.

Before combustion can take place, the temperature of the gaseous mixture must be raised to a certain degree, called the *point of ignition.* Now, if the mixture can be separated from the flame by some kind of a screen that will not become heated to the point of ignition, it is evident that it cannot be set on fire by contact with the screen.

The device most frequently employed as a fire-check is a partition of wire gauze through which the mixture of air and gas is forced to pass. As the gas passes through the meshes of the gauze, it is carried some little distance beyond the surface before it burns; consequently, the flame does not actually touch the gauze. The heat radiated from the flame rapidly heats the wires, and would soon raise them to incandescence if no cooling influence were brought to bear on them. But, the stream of cold air and gas that passes through the meshes absorbs the heat from the wires and keeps them at a moderate temperature. If there is no current through the wire gauze, and if fire be maintained on one side of it and an explosive mixture on the other, then the safety will depend entirely on the rapidity with which the cold mixture can absorb and carry off the heat from the wires. Usually the conductive power of the air and gas is not sufficient to keep the temperature of the wires below the point of ignition for any considerable length of time, and an explosion consequently results.

An explosion on one side of a gauze partition will not set fire to an explosive mixture on the opposite side, unless the force of the explosion bursts a hole in the gauze and thus permits fire to pass, because the temperature of the flame will fall rapidly, and it will die out before the gauze becomes heated to the point of ignition.

Devices other than a wire-gauze screen are sometimes used for fire-checks. The explosive mixture may be passed through metal tubes having a small bore and considerable length, or it may be passed through narrow passages between flat metal plates; the essential point is that the heat that is received from the flame shall be conducted away or dissipated so rapidly that the temperature of the metal cannot be raised to the point of ignition at the end where the mixture enters.

The mesh and the size of the wire composing the gauze are matters of great importance. The wire should be of brass or copper, woven with twenty-eight or more wires to the inch, the gauze having not less than 784 meshes to the square inch.

Gauze made of iron or tinned wire is very liable to be spoiled by rust holes, and the metal does not conduct the heat away fast enough. It should not be used for fire-checks.

COOKING APPLIANCES

HOT PLATES

14. A **hot plate** is a small stove arranged to be set on a box or table. It may have one, two, three, or more atmospheric burners set side by side, and is called accordingly a *one-holed*, *two-holed*, or *three-holed* hot plate, as the case may be. A two-holed hot plate is shown in Fig. 8. Each burner, as *a*, *a*, is supplied with a separate air mixer and cock, as *b*, *b*. Hot plates are usually connected by means of a rubber hose, to a conveniently located hose cock on the gas-pipe system, and connected to a hose coupling *c*. The hot plates may therefore be moved about or set aside as occasion requires. No oven is attached to the hot plates, but portable ovens may be set over the burners and excellent results in baking obtained.

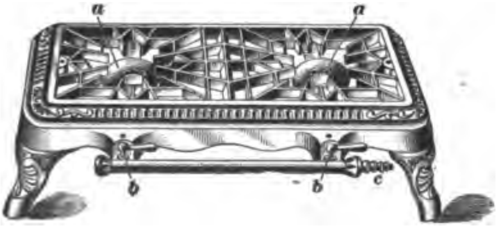

FIG. 8

The supply of air and gas should be adjusted so that the flame burns at *a* without any appearance of white tips. If the flame shows white in spots, like the flame from an ordinary illuminating burner, it indicates that not enough air is being supplied, and the flame will consequently smoke any cooking utensil that may be placed over it. If too much air is supplied, the flame will flash back through the burners, burn inside the mixing chamber, and thus become useless for cooking purposes.

GAS RANGES

15. Construction.—A gas range has usually four burners on top, as *a*, *a*, Fig. 9, and below them an oven *b*, usually 16 to 18 inches square, which is heated by one or more burners placed beneath it. The cocks for the oven burners are located at *c*; the cocks *d*, *d* are for the top burners. Gas is supplied through a ½- or ¾-inch iron pipe *e* that should be connected full size to the gas-pipe system.

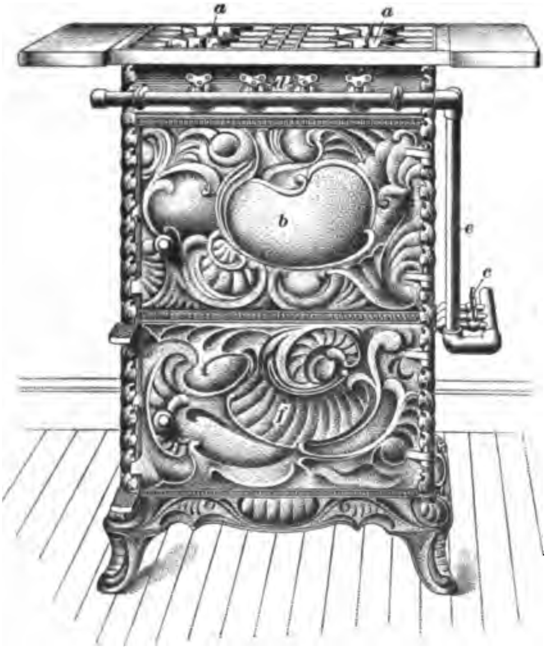

FIG. 9

Below the oven a broiler *f* is usually placed. This may be heated by the same burner or burners that heat the oven.

Gas ranges are sometimes made with only three burners on top, and sometimes with six or more burners, as in the case of hotel ranges. A good style of range in common use has four burners, and a small simmering burner inside of one of the four, so that there are then five cocks on the front of the stove. The simmering burner consumes but little gas and produces a flame just large enough to keep the food simmering. The same result can be obtained by very carefully turning down the ordinary atmospheric burner, if it is properly designed. Since the flames have to be turned down very low, however, there is danger of even a very slight draft of air extinguishing them, in which case the gas may mix with the atmosphere of the room to an extent sufficient to form an explosive mixture. To obviate this danger, all good gas ranges have a regular simmering burner. The burners used under the ovens should be so constructed as to distribute the heat uniformly to the oven and yet be capable of being checked down. It is always best for convenience and to prevent explosions to have a pilot light arranged to light the oven burners. The burners on the top of the range are of cast iron and are usually circular or star shaped.

16. Operation.—When range burners refuse to operate properly, the trouble usually arises either from the spilling of grease, etc. into the burners, in which case they get stopped up, or else from the burners being allowed to flash back and then left burning, in which case they soon fill with lampblack. In either case the burners should be taken apart and cleaned.

In advising a beginner how to operate a gas range, it should be impressed on the party that the oven burner must never be turned on unless it is lighted at once. If the oven burner is turned on, and the gas is not ignited before an explosive mixture is formed in the oven, when a light is applied to the oven burner the gas in the oven may also ignite and produce an explosion that will frighten people badly and that may possibly wreck the range. There is, however, little actual danger from such an explosion, because no burning oil is thrown about, as in an explosion of a gasoline stove.

To operate a gas range with economy, it is necessary to turn off the gas entirely when the heat is not actually needed. In baking, however, the oven should be lighted a few minutes before it is to be used. It should also be remembered that after a vessel of water has been brought to the boiling point it may be kept boiling by a very small flame.

17. Installation.—The size of meter connections, i. e., the pipe through which gas flows from the gas-pipe system to the range, is a matter that must not be slighted. Many gas ranges and heaters do not give satisfactory results, because the connections are too small. A five-light meter is the smallest size that should be used when a gas range is to be installed.

Ordinary-sized gas ranges may be connected with ½-inch pipe if the distance to be run is not more than 20 feet. If the distance is greater than this, ¾-inch pipe should be run. A ¾-inch pipe should always be run if there is any chance of a water heater being also installed. For ranges with more than four holes in the top, the supply pipe should be ¾ inch or larger. It is usually best to run the pipe line directly from the meter to the stove. A plug cock with a suitable handle should always be installed in the pipe line, and the stove should always be connected to the pipe line by means of a union or long-screw nipple, so that the gas may be shut off and the stove disconnected at any time.

BROILERS

18. The best appliance for broiling steaks and chops is a vertical broiler in which the steak is placed edgewise in a gridiron and broiled on both sides at the same time. By this means a large quantity of the juice is kept in the meat.

This style of broiler, which is shown in Fig. 10, is attached to the end of a range, or may be separate from it, and is thus frequently used in hotels and restaurants. A number of horizontal mixing tubes *a*, *a* supply a series of burners *b* located on both sides of the broiler. If these burners are in good condition, a flat sheet of blue flame will be obtained at each side of the gridiron. Most of the broilers on the market have asbestos fibers placed between the burners. These fibers become highly incandescent and heat both sides of the meat by radiation. The doors *c*, *c* can be closed over the handles of the gridiron. The products of combustion, etc. are led to the chimney through *d*.

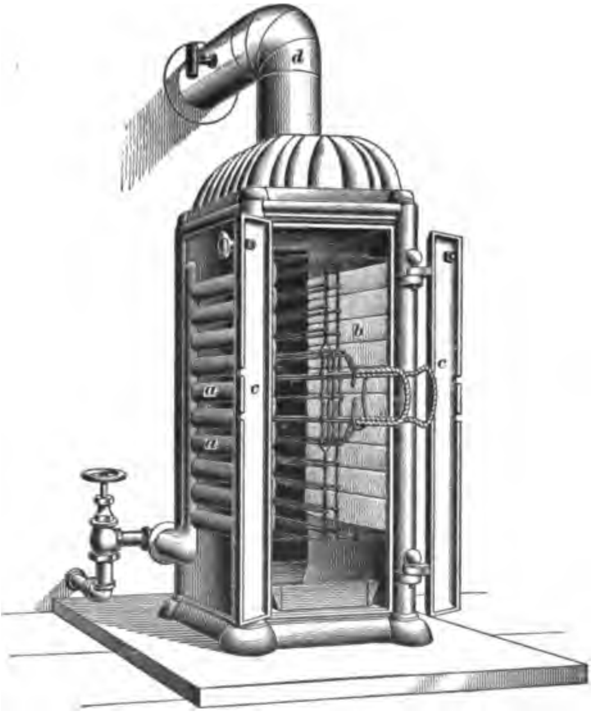

FIG. 10

HEATING APPLIANCES

HOUSE-WARMING GAS HEATERS

19. Gas Stoves.—Fig. 11 shows the interior construction of a common design of heating stove. The gas is burned in an ordinary atmospheric ring burner *a* in the base of the stove. The hot products of combustion are diluted with a quantity of air that enters through the small holes *b*, and their temperature is reduced correspondingly. They pass upwards through the interior of the drum *c* and escape to the chimney through the flue *d*. Baffle plates *e* and *f* are introduced to impede the flow of the hot gases, and to deflect them against the surface of the drum *c* and the central flue *g*. This central flue gives a very effective heating surface. The air enters at the bottom and becomes highly heated during its passage by contact with the surface of the hot metal.

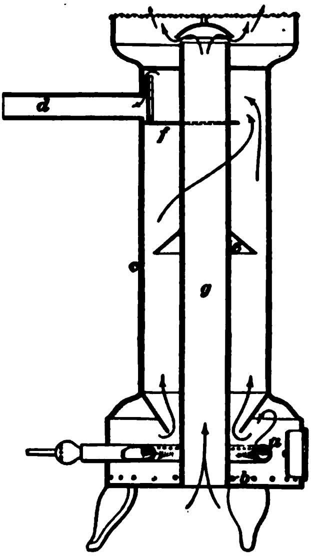

FIG. 11

20. Fig. 12 shows a **reflecting gas stove.** The gas is burned in an atmospheric burner connected to *a*, which occupies the upper part of the stove. The gas burns in a number of small jets, and the reflector *b*, which occupies the back and lower part of the stove, reflects heat from these flames into the room; being corrugated, it reflects irregularly, and thus diffuses the radiant heat. To give a cheerful appearance to the room in which such a heater is placed, the gas is sometimes burned without the addition of air before combustion.

21. Many gas heaters for house warming are built in accordance with the assumption that air can be heated by means of radiant heat. This assumption is erroneous, because radiant heat passes through air without affecting it, except in a very slight degree. It should be borne in mind that air can be heated only by contact with hot surfaces.

Nearly all the heat radiated from a stove falls on the walls or furniture of the room and is expended in warming them. The air in the room is gradually warmed by contact with the surfaces thus heated; some of it is heated by contact with the stove itself, but none of it is warmed by the direct action of the radiant heat.

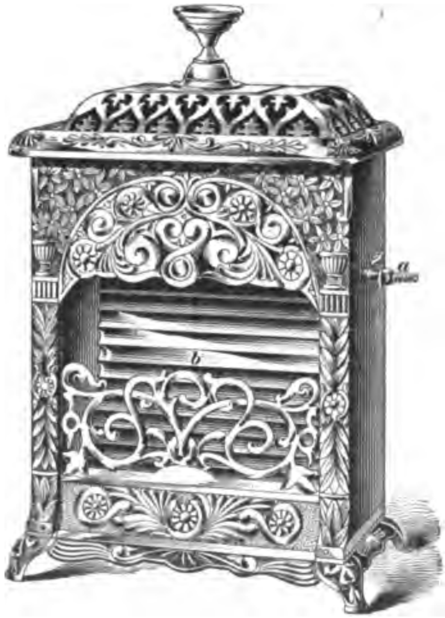

FIG. 12

The stove shown in Fig. 11 is well adapted for heating air because it has large heating surfaces over which the air may travel. The prime requisite of an air-heating apparatus is an abundance of hot surfaces.

No gas stove or heater should be permitted to discharge its products of combustion into the air of a small, closed room, because it will vitiate the air with great rapidity. Every heater in such a room should be connected by a pipe to a chimney, or should have a hood over it, which should have a free discharge into the outer atmosphere. The ordinary large rooms of dwelling houses are usually so well ventilated that small gas stoves may in many cases be used without being connected to a chimney or vent flue.

22. Open Fireplace Heaters.—Fig. 13 shows a **gas grate** designed to occupy an ordinary open fireplace. The back plate is covered with loose bunches of asbestos fibers, and is perforated with a number of fine holes. The gas is mixed with the necessary air in a chamber in the rear, and the mixture passes through the small orifices and burns on the front face of the plate among the loose fibers. The asbestos becomes incandescent, and glows like an open fire of coal, emitting both light and heat. Stoves are also constructed on the same plan, but for the reasons mentioned in Art. 21 are not very efficient in heating air.

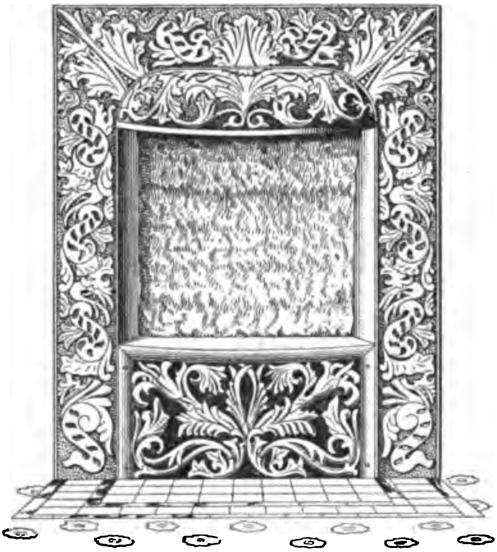

FIG. 13

23. The **Fireside Electric heater** for open fireplaces is shown in Fig. 14. It can be built into a brick wall or set in an open fireplace and thus become a stationary fixture. An atmospheric burner having asbestos fiber attached all over its face at *a* emits radiant heat direct to the room and gives a cheerful appearance. The products of combustion pass zigzag over heating tubes *b*, before they enter the chimney *c*. The space *d* is provided with an air-inlet opening of grille-work at *e*, and an air-outlet opening, also of grille-work, at *f* to allow a circulation of air over the heated surfaces and through the tubes, as shown by arrows. By this arrangement a large amount of heat is absorbed from the hot products of combustion before they enter the chimney, and this heat is utilized in warming the air in the room. To prevent the products of combustion from passing too quickly to the chimney, the draft through the zigzag outlet flues should be checked down by a damper in the collar *g*, which may be operated by a rod passing through the front and terminating with a knob, as at *h*.

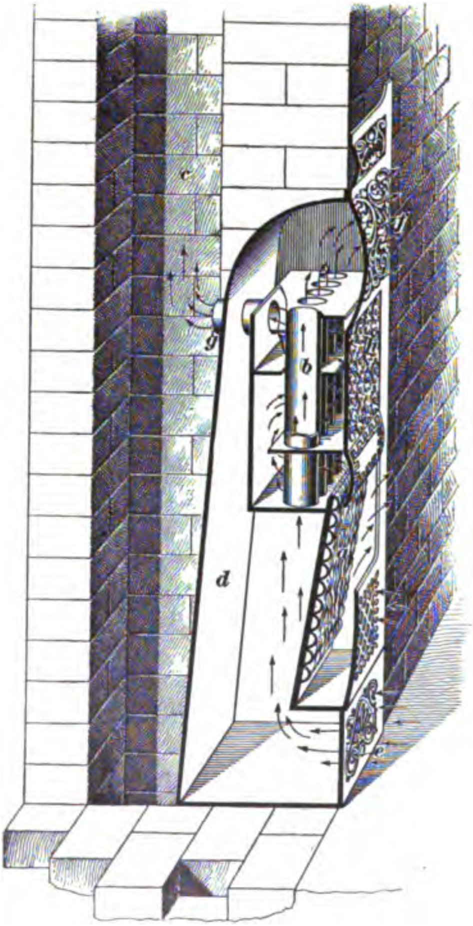

FIG. 14

24. A **gas log** is shown in Fig. 15. The log is made of fireclay, and is perforated with a large number of small holes, through which the mingled gas and air, or the gas only, passes out and burns. The log is hollow, and its interior serves as a chamber in which the gas and air are mixed before combustion. The heat is radiated directly from the small flames that nearly cover the surface of the log.

Gas logs formerly were not provided with atmospheric burners, but they had such a tendency to smoke and become covered with soot that now a mixing chamber is almost always provided. A cock or valve controlling the log should always be placed near one corner of the fireplace. Plug cocks, with special long handles having a small wheel on top, are better than valves, as they are less apt to leak.

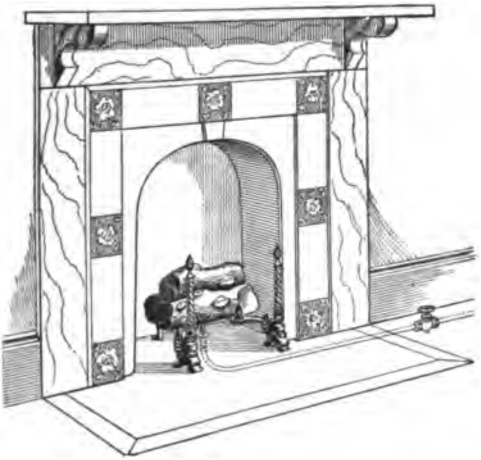

FIG. 15

When logs are set on the first floor of a house, the cocks should be placed below the ceiling in the cellar, so that they are readily accessible. Where it is necessary to place the cock between the floor and the ceiling of the room below, as in the case of logs set on second floors, a pocket should always be left in the floor above the cock in order to make it accessible for inspection and repairs. Half-inch pipe should be used to connect logs 18 inches long or less. Larger pipe should be used for larger logs.

25. Asbestos-backed gas fireplaces are more efficient heaters than logs. They are frequently provided with a gas valve at the bottom of the heater, but it is best to also place a cock on the pipe line in the same position in which a cock would be placed for a gas log.

MISCELLANEOUS GAS HEATING APPLIANCES

26. A large number of small gas heating appliances are in common use, such as coffee urns, oyster stewers, confectioners' gas stoves, waffle stoves, cake griddles, iron heaters for tailors and for laundry use, etc. Irons heated by a burner inside of them are frequently used in large laundries. By their use, considerable time is saved, as the iron is always at the right heat and the operator does not have to stop to change irons. The best irons for this use have an air-hose connection as well as a gas-hose, and an air blast is supplied to the burner. These special appliances differ only in form from the appliances described; they employ the same principle of operation, which is the burning of the gas in atmospheric burners.

In the mechanic arts, gas heating appliances are being largely used for melting metals, annealing, soldering, hardening and tempering, case hardening, and similar manufacturing operations.

WATER HEATERS

27. Classification.—Waterbacks, i. e., water heaters of the form used in coal-burning cooking stoves for heating the water for kitchen boilers, cannot be used economically in connection with gas ranges because the amount of heating surface they contain is too small. Hence, special gas-burning water heaters overcoming the defect of the waterback are made.

Gas-burning water heaters may be divided into two general classes: *kitchen-boiler heaters* and *instantaneous heaters*.

Kitchen-boiler heaters, as implied by the name, are used in connection with a kitchen boiler, serving as a storage reservoir for the hot water.

Instantaneous heaters have no storage reservoir; they are put in operation whenever hot water is required, and derive their name from the rapidity with which they will heat the water. There are two types of instantaneous heaters: (1) those in which the gases of combustion do not come into contact with the water; (2) those in which the gases of combustion come into contact with the water. The first type of instantaneous heaters may be called *closed heaters*, and contain water under pressure; the second type may be called *open heaters*, and the water in them is not under pressure.

28. Kitchen-Boiler Heaters.—The heaters that are used in connection with boilers are usually formed either of a collection of drop tubes, or of an iron casting made with hollow flanges, which gives a large heating surface, set over an atmospheric burner. A common design of kitchen-boiler heater employs a vertical cylindrical coil of copper pipe, through which the water may pass, and uses an atmospheric burner at the base of the coil, passing the hot products of combustion up the interior of the coil and between its convolutions. A heater of this kind, suited to a 50- or 60-gallon boiler, usually contains about 35 lineal feet of $\frac{3}{4}$-inch copper tubing, and the burner is made to consume from 20 to 25 cubic feet of ordinary illuminating gas per hour.

29. The inlet for the water is always at the bottom and the outlet at the top when the heater is connected to a boiler. There is usually a pilot light for lighting the atmospheric burner. The pipe leading to the bottom of the heater should always be connected to the pipe from the bottom of the boiler, and the outlet of the heater should be connected in at the top of the boiler. A good heater so arranged will heat up a 30-gallon boiler in 15 minutes.

30. The same boiler may be connected both with a gas heater and with an ordinary range waterback, and either or both may be used, as is desired. Fig. 16 shows a gas heater *a* connected to a kitchen boiler *b*. The heater is connected to the boiler independently of the connections from the kitchen-range waterback *c*, so that each may be operated separately and without interfering with the circulation of the other. When water is heated in *a*, it rises in the flow pipe *d* and enters the top of the boiler, while a corresponding quantity of cold water flows from the bottom of the boiler into the heater through the return pipe *e*. A circulation is thus maintained between the heater and the boiler, as shown by the arrows, and the heat of the gas flames is thus transmitted to the water. Gas is supplied to the burner by the pipe *f*. The products of combustion may pass to the chimney through a 3-inch or 4-inch smoke pipe, or, if the kitchen is well ventilated, may be discharged directly into it, as is done in the case illustrated in Fig. 16. The construction of the gas heater shown connected up in Fig. 16 is illustrated in Fig. 17. It is composed of a number of hollow cast-iron or cast-brass

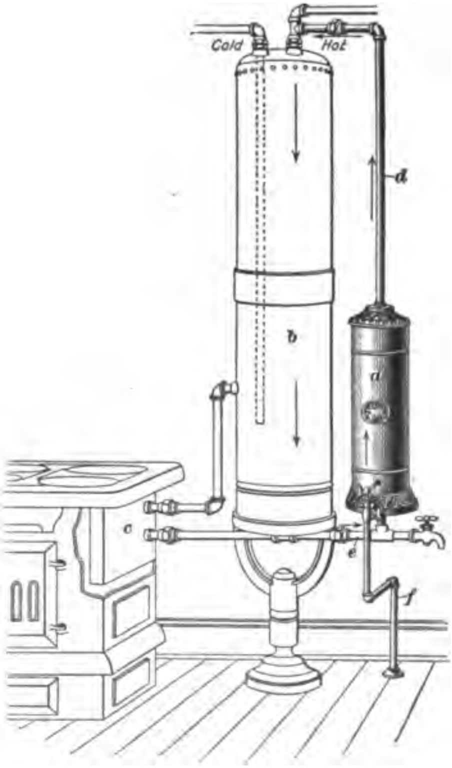

FIG. 16

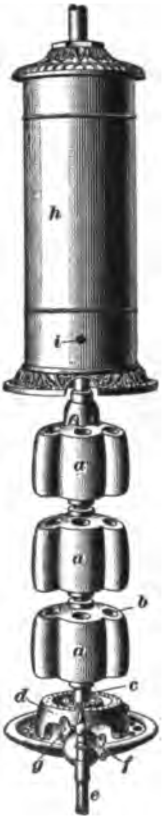

FIG. 17

sections *a*, *a*, each having a number of flues, as *b*, passing through them. The sections are connected together by nipples, the lower nipple *c* being attached to the water-supply pipe. A double-ring atmospheric burner *d* is supplied by a gas pipe *e*. The gas-cock for *d* is located at *f*, while *g* is the pilot-light cock. The sheet-metal cylindrical casing *h* is shown raised over the flow pipe; this shows how easily the heater can be inspected and cleaned. The hole *i* is for the pilot light, which, when lighted, throws a long thin flame through this hole and over the atmospheric burner. To start the heater, the pilot light is ignited first; the gas is then turned on to the ring burner, and as soon as this is lighted, the pilot light is shut off.

31. Gas water heaters will fail to give satisfaction when they are wrongly connected, and hence the points to be guarded against are here given. It is wrong to connect a heater to the side tapping of a boiler, because the entire boiler must then be heated before hot water can be drawn from the hot-water faucets. The proper place to make the connection is on top of the boiler to the hot-water pipe, as shown in Fig. 16. It must never be made as shown in Fig. 18. An air lock is formed at *a*; and the heater is then said to be *air bound*. The air is liberated from the water while it is being heated and will continue to

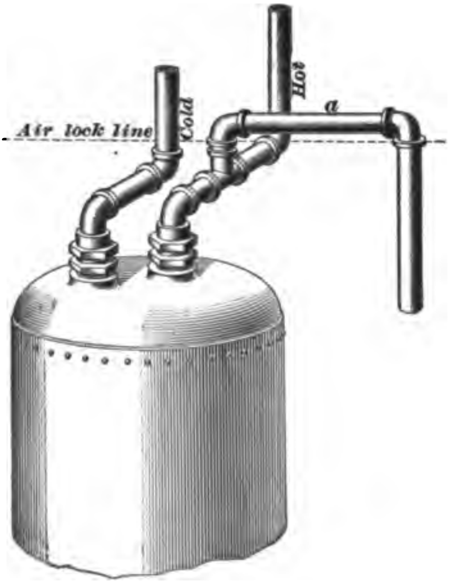

FIG. 18

accumulate in the pipe *a* even though drawn off periodically by a petcock. The air will prevent a circulation between the heater and the boiler. The heater will generate steam and produce a disagreeable noise by water hammer. The principal object in connecting the heater to the top of the boiler is to give hot water at the faucets before the boiler is warm.

It is also necessary to prevent mud or sediment that naturally gathers in the bottom of the boiler from choking the lower or return pipe to the heater. A chokage here will prevent circulation and thus produce water hammer in the heater by the generation of steam. It is therefore necessary to provide a sediment cock to allow the boiler and heater to be blown off, that is, emptied, occasionally.

Stop-cocks and valves should never be placed on the circulation pipes between a gas heater and a boiler, or between a range waterback and a boiler, because some person through ignorance may close these valves while the gas is burning in the heater and thus cause an explosion.

Gas water heaters for boilers should preferably be provided with a flue connection to a chimney to carry off the gases of combustion. This should always be done where the ventilation of the kitchen is poor, as usually is the case in city houses.

The chief trouble experienced in the use of water heaters is due to the accumulation of soot and lampblack caused by the burner being allowed to blow back and burn in that way for some time. The soot forms an insulating covering on the heating surfaces, which prevents the water from being heated properly. To remedy this, clean the heater thoroughly inside and adjust the air mixer to admit the proper proportion of air to the gas. Heaters should never be lighted unless the water is free to circulate through them, since otherwise the extreme heat may burn or warp the parts and thus cause the heater to leak.

There is usually a small amount of drip from water heaters, even when all water connections are tight. This comes from the water vapor, produced in the combustion of the gas, which is condensed by the cool surfaces of the heater when the water has not yet been raised to near the boiling point. Small pans are often provided to catch this drip.

In some cases, thermostats are set in the boiler and connected by the gas supply cock to the heater, in order that when the temperature of the water in the boiler reaches a certain point, the gas will be automatically turned down, being turned on again automatically when the temperature begins to drop.

32. Closed Instantaneous Water Heaters.—A special form of heater that does not employ a boiler or other storage reservoir, is used for heating small quantities of water to the boiling point in the least possible time. The heater is usually placed in the kitchen over the sink, or at the bathtub or bowl where the hot water is required. Owing to the rapidity with which heaters of this kind will heat water, they have been given the name of instantaneous water heaters. Fig. 19 shows the interior construction of one of these devices. The water is heated in the coiled pipe *a*. It enters at the bottom, passes gradually upwards, and is discharged at the top through a faucet, not shown in the

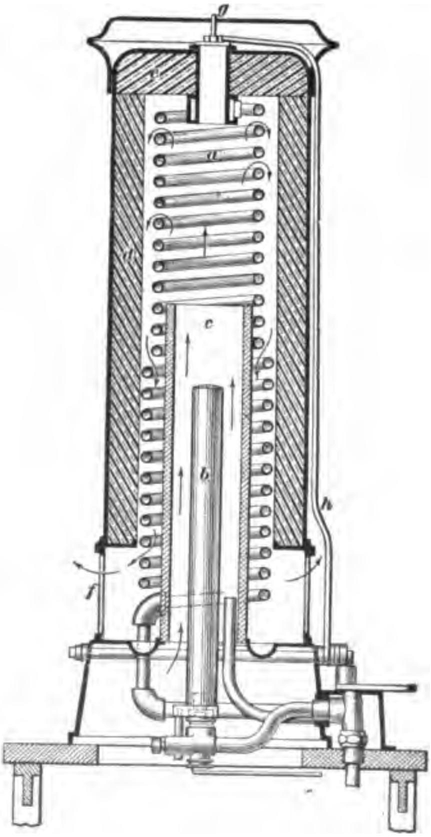

FIG. 19

figure. The burner *b* is an ordinary Bunsen burner, and the chimney *c* is made just large enough to admit the air necessary for perfect combustion. The pipe coil is surrounded by a casing *d* and *e* of firebrick, which prevents loss of heat. The hottest part of the flame plays on the upper part of the coil, and the hot gases pass between its convolutions and escape downwards, as shown by the arrows, passing out through holes in the base ring *f*. The heat is thus applied to the coil in a very effective manner, and a moderate stream of hot water can be obtained continuously.

In heaters of this kind there is danger that an explosive mixture of gas will remain in the top of the fire chamber when the burner is shut off, and blow badly when a light is applied. This is prevented by means of a damper *g*, which is connected by a rod *h* to the handle of the gas valve, so that it will remain open as long as the gas is shut off.

33. Automatic instantaneous heaters in which the water does not come into contact with the products of combustion are designed to take the place of both heater and boiler. Such heaters consist of one or more very large burners under a water coil or casting having a very large surface exposed to the heat. They are usually placed in the cellar, and the hot-water pipes run from them to all parts of the house, just as from an ordinary house boiler. A valve is placed in the cold-water inlet pipe of the heater and connected to another valve on the gas supply pipe in such a manner that when a hot-water faucet is turned on in any part of the house, the gas is automatically turned on at the heater by the opening of the cold-water valve there.

Fig. 20 (*a*) shows a heater of this type set up and connected. In Fig. 20 (*b*) the upper half is tilted over to show the construction of the interior. The atmospheric burners at *a* are supplied with gas through an automatic gas valve *b*. A shut-off valve *c* is also placed on the gas pipe, but this is left open when the heater is in use. A pilot valve *d* controls the pilot burner *e*. The pilot light is allowed to burn all the time. Cold water enters the heater through a special valve *f*, flows through the heating coil *g*, over which the flames from the burners play, becomes heated, and leaves the heater through *h*, and flows to the open faucets.

The form of heater illustrated by Fig. 20 can be used to supply a number of hot-water faucets located throughout a building. The nearer it is located to the faucets the quicker will the hot water be drawn, since with a faucet located a long distance from the heater considerable time is spent in waiting for the cold water to be drawn from the line before the hot water reaches the faucet.

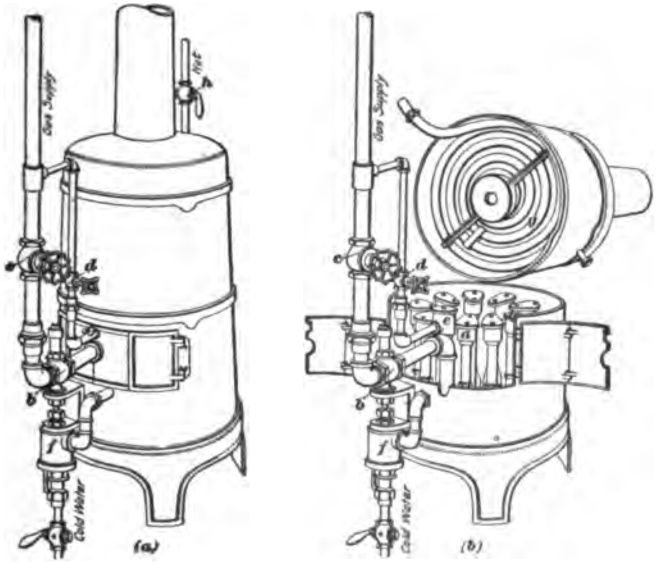

FIG. 20

The proportions of the burner and heating surface are such that the water is heated nearly to the boiling point as fast as it goes through the heater. As soon as enough hot water has been drawn, the faucet is closed. The water pressure in the house pipes at once rises to that of the street mains, and the water valve on the heater closes and the gas valve is shut off at the same time. These heaters, while they burn a large amount of gas when in operation, are very economical because no gas other than the small amount used in the pilot light is burned when hot water is not actually being used. The gas supply pipe for such a heater should never be smaller than 1¼ inches, and a connection to the chimney should always be provided to carry off the products of combustion. At least a 20-light meter should be employed to measure the gas used by the heater.

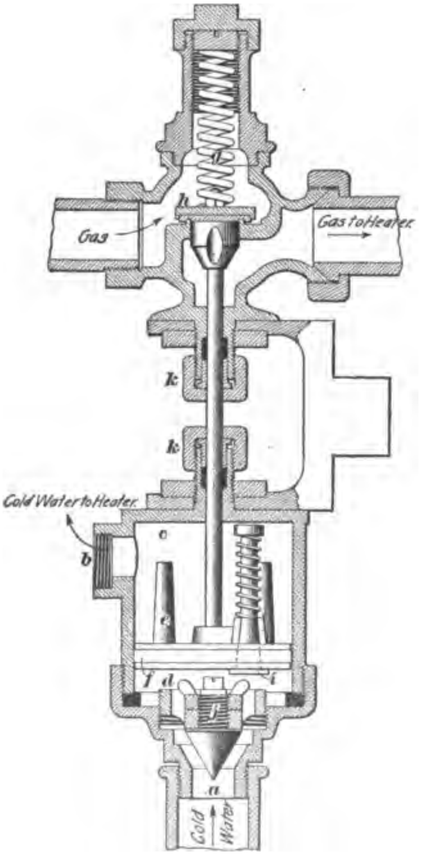

FIG. 21

34. The automatic gas and water valve shown at *b* and *f*, Fig. 20, is shown in section in Fig. 21. The end *a* is screwed to the cold-water supply pipe, and the tapping *b* connects to the heater coil. When no water is being drawn at the hot-water faucets, the water pressure in the space *c* is equal to that in the space *d*, because a small hole through the tube *e* allows the pressures to equalize. But, when a hot-water faucet is opened, the pressure falls in *c* and the pressure in *d* will instantly raise the piston *f* against the pressure of the spring *g*, which bears down on the gas valve *h*. The gas then flows freely through the gas valve to the burners in the heater, where it instantly becomes ignited by the pilot light. When the plunger is raised, the valve *i* is opened to admit a reasonable quantity of water to enter *c* from *d* and to regulate the flow and the difference in pressure between *c* and *d*. A volume regulator or check is sometimes located at *j*, as shown, when the pressure is high. Stuffingboxes are placed at *k*, *k*. The adjustment of the valve is made by regulating the tension of the spring *g* by means of the nut shown on top.

35. Open Instantaneous Water Heater.—Low-pressure automatic instantaneous water heaters may be constructed in different ways, a popular form being that in which the water comes in contact with the products of combustion. Such heaters are designed for use in bathrooms, etc., where the water is used at once and for external use only. Fig. 22 shows a heater of this type. It is composed of an outer casing, a set of atmospheric burners at the base, and specially arranged heating plates, both perforated and plain. The water flows over one side of the plates, while the flame and hot gases come into contact with the other side; hence, the water is quickly heated as it flows toward the outlet nozzle. Gas flows to the heater through a valve *a*, feeds the burners at *b*, and heats the internal plates *c*, *d*, and *e*. The

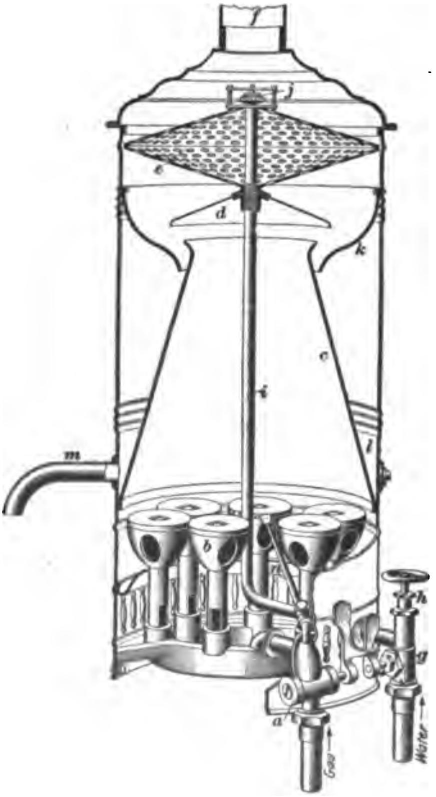

FIG. 22

flames strike directly against the surface of *c*; the gases of combustion impinge against the under side of the thin bell *d*. Their course is then diverted, and the gases rise through the perforations in the plates forming the chamber *e*, escaping to the chimney through a vent flue *f*. Water enters the heater through the valve *g*, which is hooked to the gas valve in such a manner that when the gas valve *a* is open the water valve must also be open. This prevents the heater from being lighted while the water is not flowing through it, and thus prevents the burning of the plates, which are very thin. The water valve *g* is furnished with a checking-down valve *h* by which the flow can be regulated to that best adapted for the successful operation of the heater.

When the gas-cock is turned on, the cold water immediately flows through the tube *i*, and is distributed by the spreader at *j* over the upper surface of the upper perforated plate of the chamber *e*. The water then percolates through the perforations at the top and bottom of *e*, and falls by gravity on the top of the bell *d*, from which it flows into the funnel *k*, which guides it against the upper neck of *c*. The water then runs down in a thin sheet over the outer surface of *c* to the water-collecting chamber *l*, from which it flows by gravity, quite hot, through the outlet nozzle *m* that projects over the fixture to be supplied with hot water. The tube *n* supplies a small pilot light in the center of the burners, which is used to ignite them and may burn all the time. Since this is an open heater, and hence cannot be used under pressure, it must always be located above the fixture to be supplied with hot water. This type of heater is the most economical in the use of gas, but it has the disadvantage of not being able to supply more than one or two fixtures, which must be close together.

36. A ¾-inch gas supply pipe, if short, should be run to the heater. If longer than 25 feet, a 1-inch pipe should be used if the gas pressure is 2 inches or less. A flue connection should be made in all cases, as the products of combustion generated by such a large consumption of gas in a room the size of the ordinary bathroom renders it dangerous to use the heater without a flue pipe. In common with all other gas appliances having large chambers in which gas may accumulate, these heaters are liable to explode if the gas is turned on for some time before it is lighted.

Generally, these heaters are set on a shelf in the bathroom between the bath and basin. One outlet may then be made to the bath and another outlet to the basin, a valve being placed on the nozzle that delivers water to the bath and a gooseneck bend on the nozzle that delivers water to the basin. Then, if the bath valve is open, the hot water will flow to the bath only. If the bath valve is closed, the water will rise in the chamber *l* until it overflows through the gooseneck to the basin.

PLUMBING MATERIALS AND TOOLS

PLUMBING MATERIALS

INTRODUCTION

DUTIES OF THE PLUMBER

1. It is the **duty** of the plumber to provide dwellings and other buildings with systems of piping that will (1) supply and distribute water to convenient points; (2) receive and conduct away all dirty and refuse water; (3) conduct away and dispose of all filth, excreta, and other sewage matter, and remove all noxious odors arising therefrom. He also provides apparatus for heating, pumping, storing, and measuring water, as well as lavatories, baths, laundry tubs, sinks, water closets, urinals, cesspools, drains, etc.

The comfort and healthfulness of dwellings, especially in towns and cities, depend in a great measure on the adequacy and thoroughness of the plumbing. As the health of the inmates is seriously affected by defective drainage, it is necessary that the work of the plumber shall be thoroughly and conscientiously performed. The general public is profoundly ignorant of the importance of thorough drainage, and in many cases the plumber must protect people against the evil consequences of their own ignorance. In many

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communities laws have been made that greatly aid him in constructing drainage systems as they should be.

To do his work properly, it is necessary that he should possess a complete knowledge of the nature of the materials that may be used for his purposes. He should also become familiar with the mode of performing the necessary operations upon them, both the shop work and the outside work; and he should acquire a clear comprehension of what is necessary to constitute an efficient and satisfactory system of water supply, a safe and reliable system of drainage, and a complete and convenient outfit of fixtures and domestic apparatus.

PLUMBERS' SUPPLIES

2. The supplies needed by the plumber consist of two classes—*plumbing materials* and *plumbing fixtures.*

Under the heading of **plumbing materials,** it is customary to classify the raw materials, as sheet metals of various kinds, solder, oakum, asphaltum, plaster of Paris, pipes of various kinds, pipe fittings, cocks and valves, and similar materials that are either worked, by the plumber, into a shape suitable for the purpose, or are used for connection to the plumbing fixtures, or directly form part of the connection.

The general term of **plumbing fixtures** is applied to such manufactured articles as sinks, tubs, lavatories, drinking fountains, baths, urinals, water closets, etc. that are installed in residences and public buildings.

SHEET METALS

SHEET LEAD

3. Sheet lead is commercially pure metallic lead that has been rolled into sheets by passing blocks of the metal to and fro between heavy rolls until it has been rolled out to the desired thickness. This product is known as **milled sheet lead.** It is the only kind that can be obtained from plumbers' supply houses (i. e., the firms or stores that supply material to plumbers), unless special orders are given to furnish **cast sheet lead.** This latter kind is made by first leveling a bed of fine molding sand, having the size and shape of the sheet desired, the sides and ends being formed into little embankments to prevent the molten lead running out of the bed, then pouring clean molten lead on the bed, and before it has set drawing a straight-edged board over it to give the lead a uniform thickness. Milled lead is much cheaper and stronger than cast lead, but it is not as soft nor so easily worked into different shapes. Cast sheet lead is so seldom used nowadays that manufacturers and dealers always assume that milled lead is wanted by their customers when no particular kind is specified.

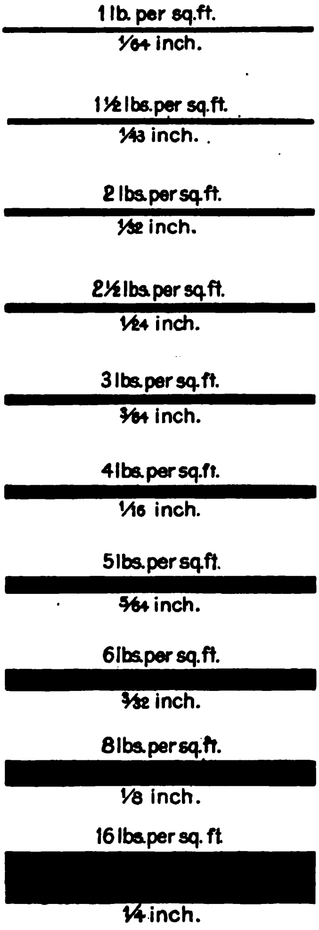


FIG. 1

4. Sheet lead is very malleable and can be worked into almost any shape. Its tenacity is low, and it is apt to tear if stretched very much. It becomes hard and brittle if subjected to much bending or beating. Sheet lead is always specified and designated by its weight per square foot; thus, sheet lead weighing 6 pounds per square foot is called **6-pound sheet lead.** It is manufactured in any thickness, weighing from 1 to 32 pounds, or more, per square foot. Fig. 1 shows the actual thickness of sheet lead of the several weights. Sheets weighing less than 2½ pounds per square foot are too light to be used in the plumbing trade. The kinds in common use vary from 4 to 8 pounds per square foot. The weights generally carried in stock by merchants are 2, 2½, 3, 3½, 4, 4½, 5, 6, 7, and 8 pounds per square foot. Sheet lead is shipped to plumbers in rolls, similar to that shown in Fig. 2, varying in width from 3 feet 6 inches to 9 feet, according to order. Owing to the fact that sheet lead is easily cut and bruised by rough handling, it is advisable to have it shipped in boxes. Special sheets for use in chemical manufactories, oil refineries, etc. can be had by special order. Sheet lead is used by plumbers in the United States of America chiefly for lining water tanks, safes under the plumbing fixtures, roof flashings, etc. But in Great Britain and other foreign countries it is used extensively by plumbers for covering flat roofs, and for ridges, valleys, gutters, and flashings of pitched roofs.

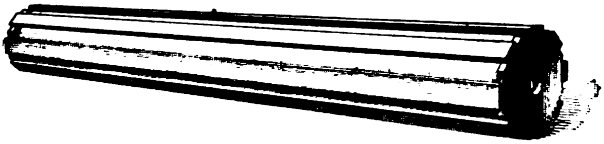


FIG. 2

SHEET COPPER

5. Sheet copper is made from copper rolled into sheets when hot by heavy steel rolls. It is supplied *soft*, or annealed, and *cold-rolled*, or with a mirror finish. Both kinds are tinned on one or both sides, or are left in the natural condition. Sheet copper is designated by its weight in ounces per square foot. The sheets in common use range from 10 to 20 ounces per square foot; the largest sheets of 10-ounce copper usually kept in stock are 48 in. × 96 in. The heavier sheets are made 60 in. × 96 in. Rolled copper has a specific gravity of 8.93. One cubic foot weighs

TABLE 1

SIZES AND WEIGHTS OF SHEET COPPER

Weight Per Square Foot. Ounces	Weight of Sheet 14 In. × 48 In. Pounds	Weight of Sheet 24 In. × 48 In. Pounds	Weight of Sheet 30 In. × 00 In. Pounds	Weight of Sheet 36 In. × 72 In. Pounds	Weight of Sheet 48 In. × 72 In. Pounds	Thickness. Inch	Stubs's Gauge Number
4	1.16	2	3.12	4.50	6	.00537	35
6	1.75	3	4.68	6.75	9	.00806	33
8	2.33	4	6.25	9.00	12	.01070	31
10	2.91	5	7.81	11.25	15	.01340	29
12	3.50	6	9.37	13.50	18	.01610	27
14	4.08	7	10.93	15.75	21	.01880	26
16	4.66	8	12.50	18.00	24	.02150	24
18	5.25	9	14.06	20.25	27	.02420	23
20	5.83	10	15.62	22.50	30	.02690	22
24	7.00	12	18.75	27.00	36	.03220	21
32	9.33	16	25.00	36.00	48	.04300	19
40	11.66	20	31.25	45.00	60	.05380	18
48	14.00	24	37.50	54.00	72	.06450	16
56	16.33	28	43.75	63.00	84	.07540	15
64	18.66	32	50.00	72.00	96	.08600	14
70		35	55.00	79.00	105	.09500	13
81		40½	63.00	91.00	122	.10900	12
89		44½	70.00	100.00	134	.12000	11
100		50	78.00	112.00	150	.13400	10
110		55	86.00	124.00	165	.14800	9
123		61	96.00	138.00	184	.16500	8
134		67	105.00	151.00	201	.18000	7
151		75½	118.00	170.00	227	.20300	6
164		82	128.00	184.00	246	.22000	5
177		88½	138.00	199.00	266	.23800	4
193		96	151.00	217.00	289	.25900	3
211		105½	165.00	238.00	317	.28400	2
223		111½	174.00	251.00	335	.30000	1
253		126½	198.00	285.00	380	.34000	0

$558\frac{125}{1000}$ pounds, while 1 square foot, 1 inch thick, weighs $46\frac{51}{100}$ pounds. The weights and dimensions of the standard sizes of sheets are given in Table I, which has been adopted as the official table by the Association of Copper Manufacturers of the United States.

6. Soft-rolled copper coated with tin on one side is generally used by plumbers for lining tanks, safes, etc. Nearly all water-closet flushing tanks are lined with sheet copper. All sheet copper furnished by some of the best manufacturers is numbered, according to its thickness, by the Stubs's gauge; all sheet brass is numbered according to Brown & Sharpe's gauge. When the name of the gauge is not given with an order for sheet brass or copper, orders are usually filled to correspond with the gauges named above. In ordering sheet metal, where gauge number or weight is unknown, the difficulty may be overcome by enclosing a sample piece with the order. In ordering sheet metal, always state the **temper** desired, that is, whether hard, semi-annealed, or soft; also state the surface finish desired, that is, whether plain, tinned, cold-rolled and tinned and polished, cold-rolled and tinned and not polished, or planished copper tinned on one side. Be careful to specify the sizes of the sheets that are best suited to your purposes. The cold-rolled copper is smooth and clean, being carefully buffed to a high polish, which, however, will tarnish, because the polished surface is not protected from the action of the weather. **Planished copper** is highly polished and coated with an elastic enamel, which prevents its tarnishing. All unprotected copper will tarnish rapidly. Copper becomes hard if it is hammered.

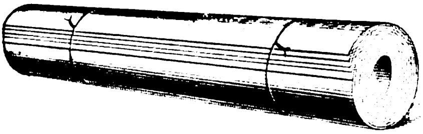


FIG. 3

7. Sheet copper is shipped in rolls, as shown in Fig. 3, and may or may not be boxed. Table II shows the sizes and weights of copper sheets in most common use:

TABLE II

STOCK SIZES OF SHEET COPPER

Kind of Copper	Size of Sheet. Inches	Weight per Sq. Ft. Ounces
Plain	24 × 48	10 to 40
Plain	30 × 60	9 to 154
Plain	48 × 72	20 to 100
Tinned	10 × 48	14
Tinned	12 × 48	14
Tinned	14 × 48	12 to 20
Tinned	24 × 48	10 to 18
Tinned	30 × 60	10 to 20
Tinned	36 × 72	16
Tinned	48 × 72	16
Tinned	48 × 96	16
Cold-rolled and tinned, polished	10 × 48	14
Cold-rolled and tinned, polished	12 × 48	14
Cold-rolled and tinned, polished	12 × 60	14
Cold-rolled and tinned, polished	14 × 48	14 and 16
Cold-rolled and tinned, polished	14 × 52	14
Cold-rolled and tinned, polished	14 × 56	14 and 16
Cold-rolled and tinned, polished	14 × 60	14 and 16
Cold-rolled and tinned, polished	24 × 48	14 and 16
Cold-rolled and tinned, polished	30 × 60	16, 18, and 20
Cold-rolled and tinned, not polished	24 × 48	14 and 16
Cold-rolled and tinned, not polished	30 × 60	14, 16, and 20
Cornice copper	20 × 96	16 and 18
Cornice copper	24 × 48	14 and 16
Cornice copper	24 × 96	14 and 16
Cornice copper	30 × 60	14, 16, and 18
Cornice copper	30 × 72	14, 16, and 18
Cornice copper	30 × 96	14, 16, 18, and 20
Cornice copper	36 × 72	16 and 18
Cornice copper	36 × 96	16, 18, and 20
Planished copper, tinned on one side	12 × 48	14
Planished copper, tinned on one side	14 × 52	14
Planished copper, tinned on one side	14 × 56	14
Planished copper, tinned on one side	14 × 60	14
Planished copper, tinned on one side	14 × 48	12 to 20
Planished copper, tinned on one side	24 × 48	14 and 16
Planished copper, tinned on one side	30 × 60	16 and 20

SHEET ZINC

8. Sheet zinc is designated by its weight in ounces per square foot. It is furnished in casks or rolls as ordered. A cask of zinc is shown in Fig. 4; this cask weighs about 600 pounds. The weights and thicknesses of the sheets are as follows:

TABLE III

SIZES AND WEIGHTS OF SHEET ZINC

Weight in ounces per square foot	10	12	14	16	18	20
Thickness in inches............	.0311	.0457	.0534	.0611	.0686	.0761

Zinc is a bluish-white metal and is highly crystalline. It is hard and brittle at the ordinary temperature and also at 400° F. But at intermediate temperatures, between 212° F. and 302° F., it is malleable and ductile, and can then be rolled into thin sheets.

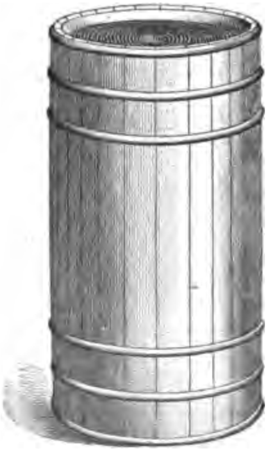


FIG. 4

NOTE.—The initial letter F. is an abbreviation of the word Fahrenheit. Thus, 400° F. means a temperature of 400° on the Fahrenheit thermometer, the one ordinarily used in this country and Great Britain. Unless otherwise stated, all degrees of temperatures will be according to the Fahrenheit thermometer, whether indicated as such or not.

Zinc is seldom used by plumbers in the United States, except for waterproofing such chambers as ice chests, or for lining corn bins in stables, or small water tanks. The weights most commonly used are 12, 14, and 16 ounce, the latter being used chiefly for tank linings.

SHEET BLOCK TIN

9. Tin in sheet form, like sheet lead, is made from solid blocks of the pure metal by the rolling process. It can be had in sheets having the same length and breadth as sheet lead;

and, like lead, is known by its weight in pounds per square foot. Owing to its lower specific gravity, tin sheets are thicker than lead sheets of the same weight per square foot. Fig. 5 shows the thickness of the common grades usually kept in stock by manufacturers. The sizes mostly used by plumbers are from 1½ to 3 pounds, inclusive, the latter being used chiefly for tanks and the former for flashing around pantry sinks, etc. To distinguish this sheet metal from tin-coated iron sheets, it is called **sheet block tin.**

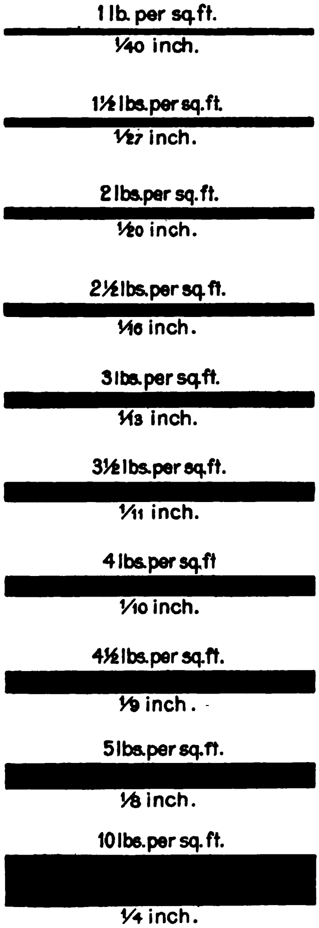


FIG. 5

SHEET IRON AND STEEL

10. Black, Galvanized, and Russia Iron.—Iron and steel in the form of sheets, called **sheet iron** and **sheet steel,** respectively, can be obtained **cold-rolled** and hard, or **annealed** and soft. Either kind can be had in the natural state, when it is called **black,** or coated with zinc, when it is called **galvanized.** Sheets range in size from 24 in. × 72 in. for the thin sheets, to 30 in. × 84 in. or larger for the heavier ones. Sheet iron is designated by its thickness as measured by a wire gauge. There are many varieties of gauges used for this purpose, which differ greatly in their measurements.

The gauge in most common use in the United States of America is given in Table IV, which has been adopted as a

TABLE IV

UNITED STATES STANDARD GAUGE FOR SHEET AND PLATE IRON AND STEEL

Number of Gauge	Approximate Thickness in Fractions of an Inch	Approximate Thickness in Decimal Parts of an Inch	Weight per Square Foot in Pounds Avoirdupois. Iron	Weight per Square Foot in Pounds Avoirdupois. Steel
0000000	$\frac{1}{2}$	.500000000	20.000000	20.4000000
000000	$\frac{15}{32}$	.468750000	18.750000	19.1250000
00000	$\frac{7}{16}$	.437500000	17.500000	17.8500000
0000	$\frac{13}{32}$	.406250000	16.250000	16.5750000
000	$\frac{3}{8}$	.375000000	15.000000	15.3000000
00	$\frac{11}{32}$	.343750000	13.750000	14.0250000
0	$\frac{5}{16}$	.312500000	12.500000	12.7500000
1	$\frac{9}{32}$	.281250000	11.250000	11.4750000
2	$\frac{17}{64}$	.265625000	10.625000	10.8375000
3	$\frac{1}{4}$	.250000000	10.000000	10.2000000
4	$\frac{15}{64}$	.234375000	9.375000	9.5625000
5	$\frac{7}{32}$	.218750000	8.750000	8.9250000
6	$\frac{13}{64}$	.203125000	8.125000	8.2875000
7	$\frac{3}{16}$	.187500000	7.500000	7.6500000
8	$\frac{11}{64}$	.171875000	6.875000	7.0125000
9	$\frac{5}{32}$	.156250000	6.250000	6.3750000
10	$\frac{9}{64}$	.140625000	5.625000	5.7375000
11	$\frac{1}{8}$	.125000000	5.000000	5.1000000
12	$\frac{7}{64}$	.109375000	4.375000	4.4625000
13	$\frac{3}{32}$	.093750000	3.750000	3.8250000
14	$\frac{5}{64}$	.078125000	3.125000	3.1875000
15	$\frac{9}{128}$	.070312500	2.812500	2.8687500
16	$\frac{1}{16}$	.062500000	2.500000	2.5500000
17	$\frac{9}{160}$	.056250000	2.250000	2.2950000
18	$\frac{1}{20}$	.050000000	2.000000	2.0400000
19	$\frac{7}{160}$	.043750000	1.750000	1.7850000
20	$\frac{3}{80}$	.037500000	1.500000	1.5300000
21	$\frac{11}{320}$	.034375000	1.375000	1.4025000
22	$\frac{1}{32}$	.031250000	1.250000	1.2750000
23	$\frac{9}{320}$	.028125000	1.125000	1.1475000
24	$\frac{1}{40}$	.025000000	1.000000	1.0200000
25	$\frac{7}{320}$	.021875000	.875000	.8925000
26	$\frac{3}{160}$	.018750000	.750000	.7650000
27	$\frac{11}{640}$	.017187500	.687500	.7012500
28	$\frac{1}{64}$	.015625000	.625000	.6375000
29	$\frac{9}{640}$	.014062500	.562500	.5737500
30	$\frac{1}{80}$	.012500000	.500000	.5100000
31	$\frac{7}{640}$	.010937500	.437500	.4462500
32	$\frac{13}{1280}$	.010156250	.406250	.4143750
33	$\frac{3}{320}$	.009375000	.375000	.3825000
34	$\frac{11}{1280}$	.008593750	.343750	.3506250
35	$\frac{5}{640}$	.007812500	.312500	.3187500
36	$\frac{9}{1280}$	.007031250	.281250	.2868750
37	$\frac{17}{2560}$	.006640625	.265625	.2709375
38	$\frac{1}{160}$	.006250000	.250000	.2550000

standard by the American Railway Master Mechanics' Association and also the Association of American Steel Manufacturers.

11. Since there are different gauges in use by the different manufacturers, and as the thickness of a sheet stamped with the same gauge number varies according to the kind of gauge used by the manufacturer of that sheet, it is advisable to specify the weight per square foot, or the thickness in thousandths of an inch when ordering sheet metal.

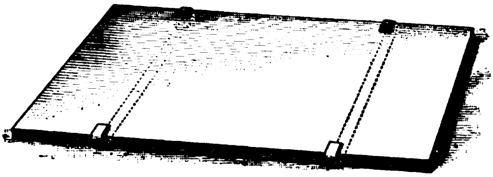


FIG. 6

Sheet iron is shipped in flat bundles put up as shown in Fig. 6, being firmly clamped together with strap-iron bands. Each sheet should be stamped with the maker's trade mark and the gauge number.

12. **Russia iron** is a class of sheet iron having its surface especially prepared to resist corrosion by a covering of flexible, transparent enamel. Genuine Russia iron is made in Russia, but American made Russia iron can now be obtained which is fully equal to the imported product.

13. **Sheet Tin.**—The article of commerce known as **sheet tin,** and also as **roofing tin,** is not tin in the true sense; it is simply a thin steel or wrought-iron sheet coated on both sides with block tin. The strength is given by the iron or steel body, and the durability by the tin coating, which especially protects the sheets when exposed to the weather. Sheet tin is generally used for roofing purposes. City plumbers seldom use it, for tinsmiths do all tin work there; but in country towns and villages the plumbers should have a fair knowledge of tin work, as they are called upon to do it. When plates are coated with tin alone, they are known as **tin plates**; when coated with a mixture of lead and tin, they are known as **terne.**

14. The original method of manufacture was to dip the plates into the melted covering material, the sheets being allowed to take on all the coating possible. Many of the best grades of roofing tin are still made by this process. Another process is known as the **patent roller process,** by which the plates are put into a bath of molten covering material and then passed between iron rolls. The pressure on the rolls leaves on the plates a thickness of coating that is determined by the distance the rolls are apart and the thickness of the sheet steel. The rolls can be adjusted to squeeze off nearly all the coating, or to leave it on, just as the manufacturer sees fit, and just as the trade will accept or reject the material.

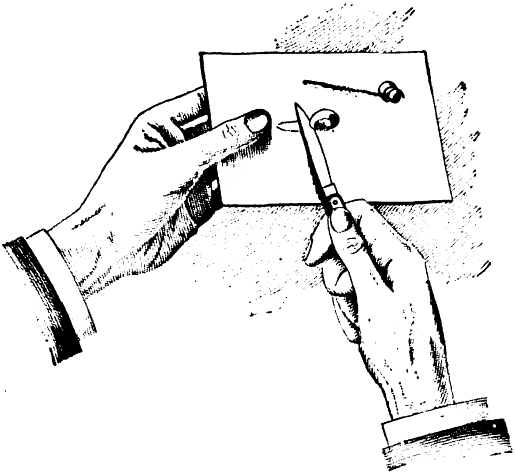


FIG. 7

15. There are different brands of roofing plates in the market at present. Some are called **double-coated,** some

redipped, others **double-dipped,** etc.; but these terms are somewhat misleading, for they seem to imply that the sheets have been dipped twice in tin.

To test tin plates, take a knife, run it over the surface and peel off the covering, as shown in Fig. 7, in order to discover its thickness. It is very important that the thickness of the coating should be tested before the tin is allowed to go on a roof.

16. To avoid trouble, the best manufacturers have an assorting department, where the defective sheets are picked out and separated from the good ones. In the manufacture of roofing plates, imperfect sheets, such as sheets with blisters, broken corners, cracks, and other flaws, occur. All these sheets are called **wasters.** These are packed by themselves, the boxes containing IC sheets being marked "ICW," and those containing IX sheets, "IXW." Wasters are

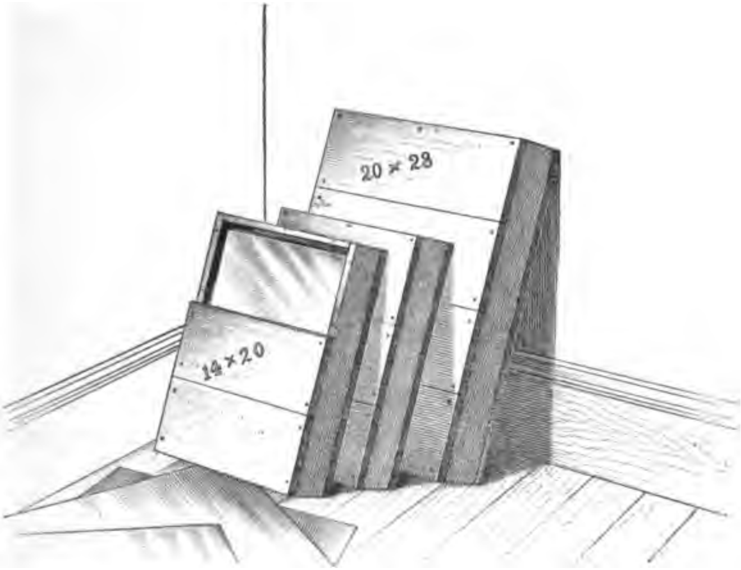


FIG. 8

always sold at prices considerably lower than the **primes**, or perfect sheets, of the same brand. Tin and terne plates for roofing and other purposes are shipped in boxes, as shown in Fig. 8.

17. There are two regular sizes of roofing plates, namely, 20 in. × 28 in., and 14 in. × 20 in. The larger size is generally used on common work, from the fact that it requires fewer seams on the roof and, consequently, cheapens the cost of laying. A third size, namely, 10 inches by 20 inches, is also supplied, and is used generally for gutters and leader pipes.

Two thicknesses of roofing plates are commonly recognized; one is the IC, which is No. 29 gauge and weighs 9 ounces to the square foot; the other is the IX, or No. 27 gauge, and weighs 10 ounces to the square foot. Sometimes a still heavier plate is called for, and it is therefore kept in stock by the best manufacturers. This plate is known as IXX, or No. 26 gauge, which is used for specially heavy work.

The standard net weight per box of IC 14 in. × 20 in. roofing tin used to be 112 pounds, or 1 pound per sheet, making 112 sheets to the box, but now it is reduced to 108 pounds. The old standard for IX plates was 140 pounds, but very few brands now weigh more than 135 pounds per box. The most reliable manufacturers guarantee the weights for the different boxes, and if the boxes do not come up to the guaranteed weight, they can be shipped back.

The best sheets on the market today are stamped with the mark of the brand, and with the designation IC or IX of the thickness.

SOLDER

18. Solder is an alloy of two or more metals which, when melted, will adhere strongly to the cleaned surfaces of other metals that are less fusible. Solders are classified as *hard* or *soft*, according to their relative fusibility. Any desired fusing point may be obtained by varying the proportions and kind of ingredients. Table V shows the composition and fusing points of the various solders in common use:

TABLE V

SOLDERS

Variety	Hard			Soft			Fusing Point Degrees F.
	Zinc	Copper	Silver	Tin	Lead	Bismuth	
Spelter, hardest	1	2					700
Spelter, hard	2	3					
Spelter, soft	1	1					550
Spelter, fine	2	2	¼				
Silver, hard		1	4				
Silver, medium		1	3				
Silver, soft		1	2				
Plumbers', coarse				1	3		480
Plumbers', ordinary				1	2		441
Plumbers', fine				2	3		400
Tinners'				1	1		370
For tin pipe				3	2		330
For tin pipe				4	4	1	

19. Hard solders are not used by plumbers, except in the exceptional cases where brass, copper, or iron tubes or other work requires to be brazed for strength. Soft solders are known to plumbers as **strap solder,** which is used for soldering with the copper bit, and **wiping solder,** which is used for making wiped joints. Fig. 9 shows a bar of strap solder of the brand known as *half and half.* Each bar weighs about 1 pound.

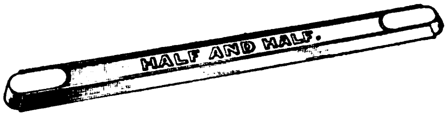

HALF AND HALF.

FIG. 9

Fig. 10 shows a bar, or ingot, of wiping solder. Each bar weighs about 5 pounds. Solder should always be purchased from the most reliable supply houses, for it is false economy to use low-grade solders.

FIG. 10

20. Making Soft Solder.—To make good solder, it is necessary to secure pure materials. The lead and tin of commerce vary considerably in purity. After deciding on the proportions of lead and tin that are required to make the desired kind of solder, the lead should be melted first, care being taken to avoid overheating the metal. The melted metal should be stirred thoroughly and the dross that floats on the surface removed. The tin should then be added, and as soon as it is melted the metal should be stirred so as to secure the thorough mixture of the lead and tin. While stirring, a small quantity of black rosin should be added. When the metal becomes hot enough to ignite a piece of newspaper, it should be skimmed and then poured into molds, care being taken that the molds are clean and dry.

The two metals will separate if the melted solder is allowed to stand without stirring, because of the difference in specific gravity of the lead and tin, their weights being in the proportion of about 11 to 7. Therefore, thorough stirring is indispensable.

21. Soft solder is quickly spoiled by overheating. Both metals oxidize rapidly at a low, red heat, but the tin oxidizes faster than the lead. A thick, yellow crust will form on the surface of the molten metal, which will exclude the air and thus retard the oxidization. If this crust is left undisturbed until the metal cools to the proper working temperature, which is not over 600°, and is then removed, the solder may be restored to proper quality by the addition of a little tin. The molten metal should not be stirred while any oxide remains upon its surface.

22. Soft solder becomes impure and useless by the gradual accumulation of oxides, or iron and brass filings, and also by contamination with zinc.

A common method of purifying impure soft solder is as follows: The metal is heated to about 800°, which is a very dull-red heat, just visible in the dark, but not visible in daylight. A quantity of sulphur is thrown upon the metal as soon as it is melted, and the metal is then well stirred, in order to bring all parts of it into contact with the sulphur. The sulphur combines with the zinc and brings it to the surface as dross. The oxides will also come to the surface; sometimes they will cling to the sides of the pot. The metal is then thoroughly skimmed (the crust being taken off whole, if possible) and allowed to cool to low working heat, about 480°, after which a little tallow is stirred into it. This will remove the last of the sulphur and the metal will appear very clean. It will probably require the addition of a little tin to restore the proper quality.

Sometimes a batch of soft solder will work well for about a dozen heats and then become unworkable. This is usually due to impurities in the tin, it being contaminated with antimony or bismuth.

As a proof that the tin will separate from the lead when the solder is in a plastic state, dig a hole in the nearly set solder in the pot, and the tin will filter down and settle in a little pool at the bottom of the hole, leaving a chalky-looking and porous metal above.

23. Testing the Quality of Soft Solder.—Having the melted solder at a temperature of about 600° (which will scorch paper, but will not ignite it), pour, as shown in Fig. 11, a little of it upon a stone that is perfectly dry, clean, and level, and form a cake as large as a dollar and about $\frac{1}{8}$ inch thick. Good solder will show a number of clear spots, from four to six to the inch, upon the top surface of the cake. If the cake turns white and chalky, the solder is probably too coarse; that is, the percentage of lead is too great. If it cools with a bright top surface, with, perhaps, a little gray or chalky center, the percentage of tin is too great.

The most certain way to test the quality of solder is to prepare a lead pipe and proceed to make a wiped joint. If the solder is good, it will cling to the pipe and remain plastic until too cool to work. If the proportion of tin is too great, it will set or harden too quickly and the metal will appear bright. Beads of tin will probably drop from the under side of the joint. If the proportion of lead is too great, it will require a long time to get up the heat, and when the joint is finished the metal will appear chalky and porous.

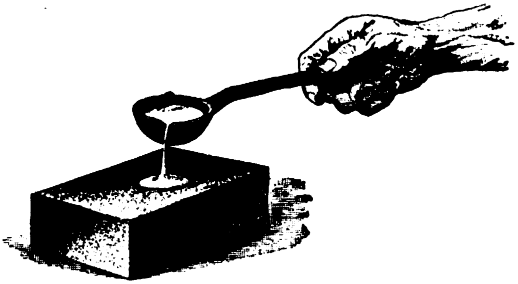


FIG. 11

24. Fluxes.—In order to aid the fusion of solder and to clean the surface of the metals to be joined, and thus promote the adhesion of the melted solder, **fluxes** are used. Table VI gives some of the most common fluxes and the metals they are chiefly used upon.

25. Chloride of zinc is prepared by mixing muriatic (hydrochloric) acid with zinc, which is in the form of grains, chips, or strips. The acid and zinc rapidly combine, and during the process a quantity of gas is disengaged, which causes the liquid to boil and emit copious fumes, which are very corrosive; considerable heat is also generated. The acid may be diluted with water to reduce the strength of the solution when desired. When the liquid stops boiling or giving off bubbles of gas, the acid is **saturated**; that is, it has dissolved all the zinc that it is capable of holding in solution.

Chemically pure muriatic acid is as clear as water, while the commercial is yellow. This is on account of the impurities it contains, such as iron, arsenic, or organic matter. The commercial is good enough to use in making the chloride-of-zinc flux.

TABLE VI

FLUXES

Flux	Metals to be Joined
Rosin	Lead, tin, copper, brass, and tinned metals (used with the copper bit or blowpipe).
Tallow (without salt)	Lead, tin, or tinned metals (used with the blowpipe or wiping process).
Sal ammoniac	Copper, brass, and iron (used with the copper bit or blowpipe).
Muriatic acid, or hydrochloric acid	Dirty zinc (used with copper bit).
Chloride of zinc	Clean zinc, copper, brass, tin, and tinned metals (used with copper bit or blowpipe).
Rosin and sweet oil	Lead and tin tubes (used with copper bit or blowpipe).
Borax	Iron, steel, copper, and brass (used with blowpipe).

MISCELLANEOUS MATERIALS

26. Oakum is composed of fibers of hemp, which are made to adhere strongly together by moistening them with pine tar. It can be obtained in bales, either loose or slightly twisted.

27. Asphaltum is a native mineral pitch or bitumen, and is found in several localities in the United States, but the greater part of the supply is obtained from European sources. It is black or dark brown in color, and has a high luster on its fractured surfaces. Its specific gravity is about 1.1. It melts and burns, leaving no residue, and dissolves completely in petroleum or turpentine. For the purpose of making waterproof coatings on brickwork, etc., it is mixed with coal tar and is put on hot. It is used for coating all kinds of ironwork that is exposed to dampness or is buried in soil. Pipes, etc., that are to be thus coated should be heated to the melting point of the asphaltum before they are dipped.

28. Plaster of Paris is used in the plumbing trade chiefly for bedding or setting marble work, making joints about wash basins, cocks, etc. It should be mixed in small quantities with water to the consistency of thick cream, and should be applied as quickly as possible, for it sets rapidly; it should not be disturbed while setting. Plaster of Paris is very porous and, therefore, is not suitable for making joints under water. If plaster of Paris begins to set while it is being applied, throw it away and mix up a fresh batch. Do not attempt to thin it out with more water.

29. Portland cement is used by plumbers for many purposes, chiefly for jointing earthenware pipes. It should not be used in the pure state, but should be mixed with an equal quantity of clean sharp sand, and then tempered with clean water into a thick mortar. If too much cement is mixed at a time, it will begin to set before it can be applied. Portland cement should not be *tempered up*, that is, thinned with water when it has begun to harden, for any purpose except for bedding or supporting the fireclay pipes. This cement will set under water; a barrel of it weighs about 400 pounds.

30. Rosendale cement is similar to Portland cement, but is not so strong and is of an inferior nature. It should be mixed with sand, the same as Portland cement, before being tempered with water. It is not suitable for jointing fireclay pipes or other work under water. A barrel of this cement weighs about 300 pounds.

31. Glaziers' putty is made by mixing about 7 parts of whiting with 3 parts (by weight) of boiled linseed oil. It is used for bedding woodwork around fixtures, and for bedding cast-iron sinks, etc.

32. Red lead is mainly oxide of lead, and is sold in kegs in the form of a heavy powder. It is prepared for use by mixing it in small quantities with boiled linseed oil just before using. It becomes very hard in setting, and is used to bed fixtures, and to set slate slabs, etc., but must not be used with marble.

33. White lead is a carbonate of lead ground to a fine paste with boiled linseed oil. It is the basis of nearly all good house paints, and is used for the same purposes as red lead.

34. Plumbers' soil is made of lampblack, water, and glue. Most plumbers prefer to buy the already prepared soil from plumbers' supply houses; some, however, choose to make it themselves. To make plumbers' soil, take a package of lampblack and mix it in a mortar with water. While you are doing this, have a kettle with about a quart of water and a tablespoonful of good glue heating on the fire. When the glue is melted, pour in the lampblack and stir the mixture while boiling for about 1 hour. Try the mixture by painting a piece of sheet lead with soil and then letting it dry; if it cracks when the lead is bent back and forth, there is too much glue; if it rubs off with the hand, it needs more glue. When the soil is cold, it should have the consistency of gelatine. Always melt the soil with heat before applying it with the brush.

35. Plumbers' paste is a mixture of water and flour that has been cooked until it has the consistency of jelly. During summer a little alum, blue vitriol, or carbolic acid can be added to prevent the mixture becoming sour. If the paste is allowed to freeze, it will lose its adhesive qualities. This paste is used for pasting paper around joints. Some plumbers even use it instead of soil for painting the pipes.

RIVETS

36. Rivets for plumbers' use are made chiefly of wrought iron and copper. Iron rivets without coating are called **black,** and when coated with tin are known as **tinned rivets.**

The **button head,** or **cup,** rivet *a*, Fig. 12, is used for joining relatively thick sheets, particularly if they are subjected to internal pressure, or where the riveted seam must be water-tight, as in an ordinary kitchen boiler.

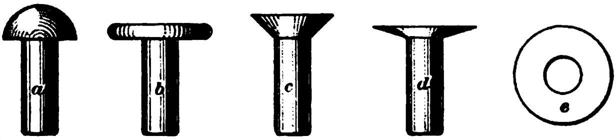


FIG. 12

The most common form of rivet used in the trade is the common **flat-head** rivet, *b*. This form is used on all classes of thin sheet-iron work. The **countersunk-head** rivet *c* is used only in joining thick sheets or plates, or other work, where the rivet head is desired to be finished flush with the material riveted.

The **braziers'** rivet *d* is made of copper and is used chiefly on sheet-brass or sheet-copper work. The **burr** *e* is generally used with the copper rivet, the burr being placed on the end opposite the rivet head. The object of using the burr is to distribute over a large surface the stresses due to the riveting, and thus avoid cracking the sheet and prevent it from bulging between the rivets.

Small rivets are put up in packages containing 1,000 rivets. Their size is designated by the weight in ounces or pounds per package.

PIPES

LEAD PIPE

37. **Lead pipe** is composed of metallic lead that may or may not be commercially pure. The purer the lead, the more soft and more pliable it is. The smaller sizes of lead pipe, i. e., the sizes used for water supply, were always made seamless by being pressed through the dies of a lead-pipe press. The larger sizes, such as those used for waste or drain pipes in buildings, were in the pioneer days of plumbing made from sheet lead. But the large field for seamless lead pipes for drainage work induced manufacturers to prepare special dies, and now they produce seamless lead pipe of all required sizes and weights, as shown in Table VII.

Lead pipes of any size differing from the weights there given are made to order.

The smaller sizes of lead pipe are known as **lead tubing**; the sizes and weights per foot, the sizes being *inside* diameter, are $\frac{1}{16}$ inch, $\frac{3}{4}$ ounces; $\frac{1}{8}$ inch, $1\frac{1}{4}$ ounces; $\frac{5}{32}$ inch, $2\frac{1}{4}$ ounces; $\frac{1}{4}$ inch, 5, 6, 8, or 13 ounces.

38. Lead pipe is shipped in coils, which are protected with straw rope if there is much danger of the pipe being injured during shipment; or, it is coiled on a wooden spool, like thread. This is a convenient method that effectually protects the pipe during shipment, and also while the coil is being unrolled.

39. The length of a coil of lead pipe from $\frac{1}{4}$ to 1 inch in diameter is about 60 feet, and the length of a bundle of lead pipe from $1\frac{1}{4}$ to 2 inches in diameter about 36 feet.

TABLE VII

WEIGHT PER FOOT OF LEAD PIPE AND TIN-LINED LEAD PIPE

Inside Diameter.	AAA Brooklyn.		AA Extra Strong.		A Strong.		B Medium.		C Light.		D Extra Light.		E Fountain.	
Inches	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.
$\frac{3}{8}$	1	12	1	8	1	4	1	0		12		10		7
$\frac{7}{16}$							1	0		13				
$\frac{1}{2}$	3	0	2	0	1	12	1	4	1	0		12		9
$\frac{5}{8}$	3	8	2	12	2	8	2	0	1	8	1	0		12
$\frac{3}{4}$	4	12	3	8	3	0	2	4	1	12	1	4	1	0
1	6	0	4	12	4	0	3	4	2	8	2	0	1	8
$1\frac{1}{4}$	6	12	5	12	4	12	3	12	3	0	2	8	2	0
$1\frac{1}{2}$	8	8	7	8	6	8	5	0	4	4	3	8	3	0
$1\frac{3}{4}$	10	0	8	8	7	0	6	0	5	0	4	0		
2	11	12	9	0	8	0	7	0	6	0	4	12		

The larger sizes of lead pipe, commonly called **waste pipes,** are much thinner in proportion to their diameter, than the smaller ones. This is due to the fact that the small pipes are intended to convey water under pressure, while waste pipes convey water at atmospheric pressure only. The weights and standard sizes of lead waste pipe are given in the following table:

TABLE VIII

LEAD WASTE PIPE

Inside Diameter. Inches	Weight Per Lineal Foot. Pounds	Inside Diameter. Inches	Weight Per Lineal Foot. Pounds
$1\frac{1}{2}$	2 to 3	4	5 to 8
2	3 to 4	$4\frac{1}{2}$	8 to 10
$2\frac{1}{2}$	4 to 6	5	8 to 12
3	$4\frac{1}{2}$ to 6	6	12 and up

Owing to the thinness of waste pipes, compared with their diameters, they cannot be coiled upon reels like the water pipes; and as they are easily injured, it is necessary to box them and ship them as straight tubes. Their length is usually about 10 feet.

40. In order to properly protect lead pipe in coils against injury in the shop or store, and also as a convenient method of storage, it should be kept in a rack, which may be constructed in any suitable manner. A very satisfactory form of a rack is shown in Fig. 13. Straight, thin, lead pipe is best kept in long boxes.

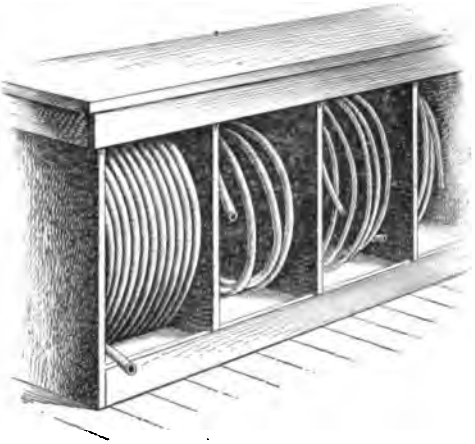


FIG. 13

TIN PIPE

41. **Tin pipe** is made in a manner similar to lead pipe, but is composed of commercially pure tin. To distinguish it from common tin pipe (iron or steel covered with tin), such as is used for furnace pipes or speaking tubes, it is commonly called **block-tin pipe.** There are many inferior grades of this pipe, the tin in them being alloyed with cheaper metals, such as lead and zinc. A high grade of tin pipe should shine like silver, if polished, and even the coil, no matter how old, should be white, but not of a bluish tint. If a piece of genuine tin pipe is bent, it produces a crackling sound; lead pipe or tin pipe heavily alloyed does not make this noise.

42. Block-tin pipe is used principally for conveying beer, ales, and spirituous liquors; also rain water, condensed water, or other pure waters, etc., which oxidize lead or otherwise affect it. The standard sizes and weights of block-tin pipe are given in Table IX; other sizes and weights are only made to order. The comparative weights of block-tin pipe are designated by A A and A A A, the latter meaning the heavier pipe.

TABLE IX

PURE BLOCK-TIN PIPE

Kind of Pipe	Diameter. Inch	Weight Per Foot. Ounces	Kind of Pipe	Diameter. Inches	Weight Per Foot. Ounces
AAA	1/4	5	AA	5/8	9
AA	1/4	3 1/2	AAA	3/4	13
	1/4	8	AA	3/4	11
AAA	5/16	6 1/2	AAA	1	17
AA	5/16	4	AA	1	14
AAA	3/8	7	AAA	1 1/4	26
AA	3/8	4	AA	1 1/4	18
AAA	7/16	7	AAA	1 1/2	36
AAA	1/2	10	AA	1 1/2	24
AA	1/2	6	AAA	2	40
	1/2	8	AA	2	26
AAA	5/8	11			

COMPOSITION PIPE

43. Composition pipe is made from a mixture of block tin, lead, zinc, and presumably other similar materials available that can be used without materially injuring the pipe. It is often used by mistake for block-tin pipe. It can be distinguished from block-tin pipe by the absence of the sharp, crackling sounds when it is bent; also by its bluish tinge. In color it usually appears about midway between lead and tin. It is shipped in coils like block-tin pipe.

TIN-LINED PIPE

44. Tin-lined pipe is simply a lead pipe with a block-tin lining, as shown in Fig. 14. The lining is not separate from the pipe, but fused to it. Tin-lined pipe has the advantages of block-tin pipe, but is much cheaper. This pipe can be distinguished by two ribs *a*, *a* that run the full length. It is more easily soldered and is more popular than block-tin pipe. The thickness of the tin lining largely determines the value of the pipe—the thicker the better. A thickness of about $\frac{1}{16}$ inch of tin lining is commonly used.

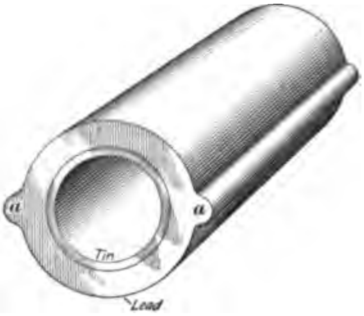


FIG. 14

Tin-lined iron pipe is plain iron pipe coated inside with block tin. The best kind is that in which the lining is fused to the iron. The pipe fittings, such as couplings, tees, elbows, etc., are also lined with block tin. In making up joints in a line of this pipe, the cut ends should be heavily tinned with solder so that no bare iron will be exposed to the fluid in the pipe.

WROUGHT-IRON PIPE

45. Wrought-iron pipe is made either *black* or *galvanized*, and all American manufacturers conform the dimensions of the pipe to a standard given in Table X.

Wrought-iron pipes are made in lengths of about 15 to 20 feet. All pipe that is 1¼ inches or less in diameter is **butt-welded;** that is, the edges are joined as shown in Fig. 15. All sizes above 1¼ inches are **lap-welded,** the edges being lapped as shown in Fig. 16. All butt-welded pipe is tested at the mills to a pressure of 300 pounds per square inch. Lap-welded pipe is similarly tested to 500 pounds pressure per square inch. Wrought-iron pipes having a greater thickness of metal than those mentioned are made and are known as **extra strong** and **double extra strong.** The extra thickness of metal reduces the bore of the pipe; the outside diameter of each nominal size is never changed. Thus, all grades of iron pipe will connect properly with standard fittings.

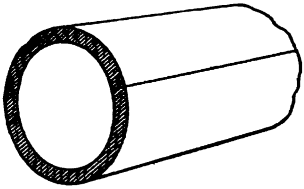


FIG. 15

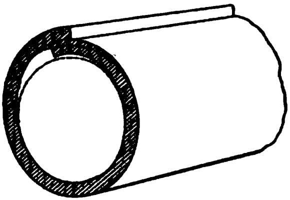


FIG. 16

TABLE X

STANDARD DIMENSIONS OF WROUGHT-IRON PIPE

Nominal Internal Diameter. Inches	Actual Internal Diameter. Inches	Actual External Diameter. Inches	Thickness of Metal. Inches	Area of Internal Diameter. Square Inches	Weight in Pounds Per Lineal Foot
1/8	.270	.405	.068	.0572	.243
1/4	.364	.540	.088	.1041	.422
3/8	.494	.675	.091	.1916	.561
1/2	.623	.840	.109	.3048	.845
3/4	.824	1.050	.113	.5333	1.126
1	1.048	1.315	.134	.8627	1.670
1 1/4	1.380	1.660	.140	1.4960	2.258
1 1/2	1.610	1.900	.145	2.0380	2.694
2	2.067	2.375	.154	3.3550	3.667
2 1/2	2.468	2.875	.204	4.7830	5.773
3	3.067	3.500	.217	7.3880	7.547
3 1/2	3.548	4.000	.226	9.8870	9.055
4	4.026	4.500	.237	12.7300	10.728
4 1/2	4.508	5.000	.246	15.9610	12.492
5	5.045	5.563	.259	19.9900	14.564
6	6.065	6.625	.280	28.8890	18.767

46. Owing to improved processes of making steel, nearly all the pipe sold as *iron pipe* is now made of mild steel. Its composition is such that analysis by experts can scarcely define a difference. The mechanic, however, can easily distinguish a difference when cutting the pipe. It wears the pipe tools more than wrought-iron pipe and rusts out more quickly. Wrought-iron pipe rusts more uniformly than steel pipe. The latter *pits* seriously; that is, corrodes in spots. Wrought iron is the better material, but steel has the market because it is the cheaper metal. The smaller sizes of wrought-iron and steel pipes are threaded on both ends, and tied up in bundles and shipped without covering, but a coupling is screwed on each pipe. Large pipes are shipped singly, the threaded ends being protected. If the plumber has no power-threading machines in his shop, it is customary to order large pipes cut and threaded to given measurements. The pipes should be stored in pipe racks near the pipe-fitter's bench.

47. Lead-lined iron pipe is simply ordinary iron or steel pipe lined with lead. The lining should not be less than $\frac{1}{8}$ inch thick for ordinary pipes, and the lead should be fused to the iron. If it is loose from the iron there is a liability, particularly if hot water flows through the pipe, of the lead collapsing and restricting or entirely choking the bore. The cut ends of the pipe should be protected in a manner similar to that specified for tin-lined iron pipe, and the fittings should also be lead-lined.

BRASS AND COPPER PIPES

48. Brass and copper pipes, or **tubing,** as they are often called, are made in all diameters and thicknesses. The size by which they are designated is always the outside diameter; the thickness of the metal must always be specified, in order to secure tubing that is suitable for the purpose in view.

Brass and copper tubes are made by two methods, and are accordingly designated as *seamless-drawn* and *brazed tubing.*

Seamless-drawn tubing is made from a solid block of metal and hence is without a joint; it is much superior in strength to brazed tubing. **Brazed tubing** is similar in structure to butt-welded wrought-iron pipe, except that the joint is secured by brazing.

Iron-pipe size brass and copper tubing is made in sizes that correspond in external diameter with the sizes of wrought-iron pipe, in order that it may be threaded with the ordinary iron-pipe dies, which every plumber has in his shop, and so that it can be screwed into the same kind and sizes of fittings that are used for wrought-iron pipe. It is seamless-drawn. Tubing of this kind should always be specified as *iron-pipe size.* It is the kind commonly used by plumbers. The market sizes and weights are given in Table XI.

49. Brass and copper pipes tinned inside should always be used when they are required to convey water for drinking or cooking purposes, otherwise the water may become poisoned to a serious extent. Brass pipes should always be annealed or semiannealed, otherwise they will split and leak. Nearly all brass tubes used in exposed plumbing work are nickel-plated, which gives them a fine finish. Nickel-plated or polished and lacquered pipes are always carefully wrapped and shipped in boxes. Plain pipes may be shipped like iron pipe. Brass pipe, iron-pipe size, semiannealed and tinned inside and outside, is used extensively on the very finest class of work.

WOODEN PIPES

50. Wooden pipes are usually made from solid square timber. The bore is made by an auger, which is forced through the center of the piece. Another kind is made by winding spirally a flexible wooden strip or ribbon upon a

TABLE XI

SEAMLESS-DRAWN BRASS AND COPPER TUBES—IRON-PIPE SIZE

Size (Nominal). Inches	Outside Diameter. Inches	Thickness. Stubs's Gauge	Weight Per Lineal Foot	
			Brass. Pounds	Copper. Pounds
$\frac{1}{8}$	$\frac{13}{32}$	15	.27	.29
$\frac{1}{4}$	$\frac{17}{32}$	15	.37	.39
$\frac{3}{8}$	$\frac{21}{32}$	13	.60	.64
$\frac{1}{2}$	$\frac{13}{16}$	12	.76	.80
$\frac{3}{4}$	$1\frac{1}{16}$	12	1.22	1.28
1	$1\frac{5}{16}$	11	1.63	1.74
$1\frac{1}{4}$	$1\frac{5}{8}$	9	2.52	2.65
$1\frac{1}{2}$	$1\frac{7}{8}$	9	2.94	3.12
2	$2\frac{3}{8}$	8	4.28	4.53
$2\frac{1}{2}$	$2\frac{7}{8}$	7	5.58	5.92
3	$3\frac{1}{2}$	5	8.35	8.84
4	$4\frac{1}{2}$	3	12.24	12.96

mandrel in such a manner that the layers overlap one another, and then securing them together with cement. It is made in all diameters and lengths up to 20 feet. Still another kind is that made of staves, which are hooped together. Wooden pipes are commonly used for conveying salt water and other liquids that are detrimental to iron.

CAST-IRON PIPES

51. Cast-iron pipes used by plumbers are of two general kinds, viz., those used for house-drainage purposes, which are known to the trade as **cast-iron soil pipes,** and those used for carrying gas or water, and known, respectively, as **cast-iron gas pipes** and **cast-iron water pipes.**

Soil pipes are made in two grades known as **standard** and **extra heavy,** the former being the lighter of the two. In practice it has been found that the standard pipe soon corrodes, and the sockets are so weak that they easily split when the joints are being calked. It has also been observed that many flaws exist in standard pipe which prevent its being gas-tight. Health departments, therefore, do not allow its use; and hence extra-heavy pipe is specified in the codes that govern plumbers.

52. Cast-iron **plain soil pipes** are made as shown in Fig. 17; they are 5 feet long, exclusive of the socket, and may be from 2 to 12 inches inside diameter. They are sold by the lineal foot.

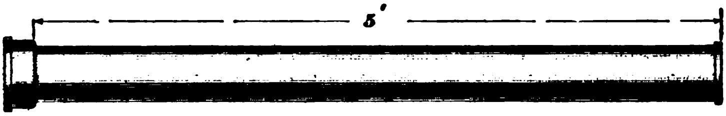


FIG. 17

53. A **double-hub pipe** is shown in Fig. 18. It differs from the plain soil pipe in that it has a socket at each end.

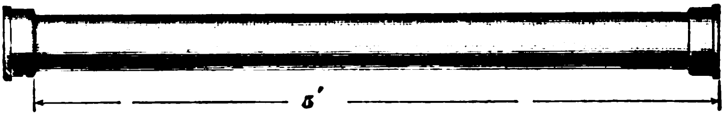


FIG. 18

In making connections with cast-iron pipe, it is often necessary to cut a pipe to the required length. If plain pipe is used, the cut-off end without the socket can rarely be used for anything, and hence is wasted; but if double-hub pipe is cut, both pieces can generally be used; hence it is the most economical pipe for cutting up. Double-hub pipes are sold by the piece; that is, it is necessary to order the desired number of lengths.

54. The best pipes, generally speaking, are those that are cast vertically, because their thickness is more uniform all around and the iron is easier to cut. Pipes cast horizontally have a rib on opposite sides running full length. This shows where the two halves of the mold come together.

55. Cast-iron pipes may be had either plain, i. e., as they come from the mold, or coated with some particular material, such as asphaltum. In ordering this kind of pipe, it should be stated whether plain or coated is wanted.

EARTHENWARE PIPES

56. **Earthenware,** or **terra-cotta, pipes,** as they are often called, are made of various kinds and qualities of clay. They are made in 2-foot and 3-foot lengths, and are provided with a socket on one end, while the other end is plain. These pipes are baked hard and are made impervious to water by a coating of salt glaze. They are also known as **vitrified,** or **tile, pipes.**

57. Vitrified earthenware pipes are commonly used for underground drainage, but never for inside drainage. The sizes usually kept in stock by dealers are 3, 4, 5, 6, 7, and 8 inches inside diameter. Perfect pipes are straight, cylindrical in form, smooth inside, and have no kiln cracks back of the hub, or elsewhere. The inside of the sockets and the outer surface of the other end should not be glazed, for these surfaces must be cemented together in making the joints, and cement does not adhere properly to a glazed surface. The pipes in common use, however, are glazed all over because it is cheaper to make them thus, and because there is little demand for the kind above described.

PIPE FITTINGS

GAS- AND WATER-PIPE FITTINGS

58. Figs. 19 and 20 show an assortment of malleable-iron **pipe fittings.** These can be had **beaded** or **plain,** and some of either kind are shown. The beaded fittings are the strongest and best, for the bead, which will be noticed around the outside edges of the threaded openings, is a reenforcement that prevents the fitting from being split when the tapered thread is screwed into it. Their use is recommended. The plain fittings have about the same thickness in every part. The names of the different fittings, all those here shown being for ¾-inch pipe, are given below.

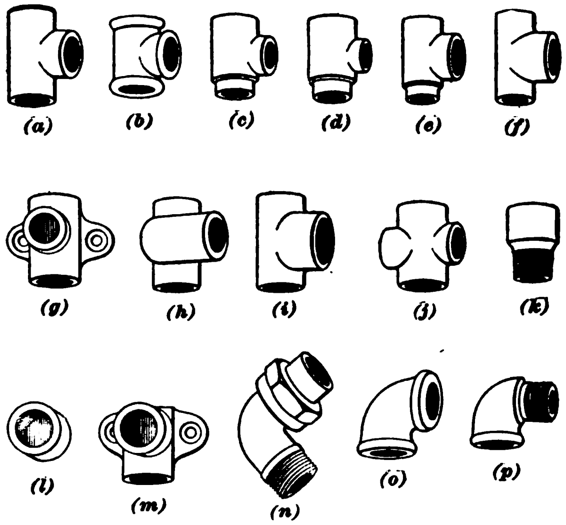


FIG. 19

59. Fig. 19 (*a*) shows a ¾-inch **plain T,** or **tee**; that is to say, it has a ¾-inch straight *run* and a ¾-inch *branch.* The **run** of a tee is the line through the largest opposite openings. The other openings are called the **branches.** In the case of crosses, the run is always considered to be the line through the largest opposite openings. In ordering tees and crosses, always give the sizes of the run first, then the branches; this will prevent confusion in filling the orders.

Fig. 19 (*b*) represents a ¾″ × ½″ **beaded tee**; that is, it has a ¾-inch run and a ½-inch branch. An illustration of a ¾″ × ½″ × ½″ **reducing plain tee** is shown in Fig. 19 (*c*). This is used to connect two ½-inch pipes and a ¾-inch pipe, the run being reduced from ¾ to ½ inch.

A ¾″ × ½″ × ⅜″ reducing plain tee is shown in Fig. 19 (*d*). Fig. 19 (*e*) shows a ½″ × ⅜″ × ¾″ **bull tee.** Fig. 19 (*f*) illustrates a ½″ × ¾″ **plain bull tee.** In Fig. 19 (*g*) is shown a ¾″ × ½″ **drop tee** which has two lugs, one on each side of the run, by which the fitting is screwed to the wall. It takes the name of drop from the drop fittings so commonly used in gas-pipe work.

A ¾″ × ¾″ **plain cross-over tee,** used where a branch has to cross over the top of another pipe, is shown in Fig. 19 (*h*). Fig. 19 (*i*) shows a ¾″ × 1″ plain bull tee, used to screw on the end of a 1-inch pipe, which supplies two ¾-inch branches at right angles. Fig. 19 (*j*) represents a ¾″ × ½″ plain cross for a ¾-inch run and two ½-inch branches. If it had a ½-inch and a ⅜-inch branch, it would be known as a ¾″ × ¾″ × ½″ × ⅜″ reducing plain cross.

In Fig. 19 (*k*), a **plain extension piece** is illustrated. The upper end is tapped ¾ inch, and the other end is threaded ¾ inch. It is used to extend a piece of pipe just about the length of the thread.

An illustration of a ¾-inch **plain cap,** used to close the end of a pipe by screwing over it, is given in Fig. 19 (*l*). A ¾-inch **plain drop L**, commonly used over a sink at the back of the faucets, the lugs being screwed to the wall to secure the faucets, or for other work, is shown in Fig. 19 (*m*).

Fig. 19 (*n*) shows a **boiler coupling**; the male end screws into the boiler, and the female end attaches to the piping. A washer is used between the faces of the union, to make a tight joint when the hexagon coupling ring shown is screwed up. Fig. 19 (*o*) represents a ¾-inch **beaded quarter L**, called a *quarter* because it is a right angle, or the fourth part of a circle. In Fig. 19 (*p*) a **beaded street L**, of which one end is threaded male and the other female, is illustrated.

60. A ¾" × ½" **plain reducing L** is shown in Fig. 20 (*a*). An illustration of a ¾-inch **eighth beaded L**, called *eighth* because it bends 45°, or one-eighth of a circle, is given in Fig. 20 (*b*). Fig. 20 (*c*) shows an **offset** formed by screwing two ¾-inch beaded eighth L's together with a close nipple between. A *close nipple* is a piece of pipe with two threads run so closely together as to touch each other. This allows the fittings to come together, shoulder to shoulder, as shown. A ¾-inch **beaded straight cross-over** for use on a straight line of pipe where it crosses over another pipe is shown in Fig. 20 (*d*).

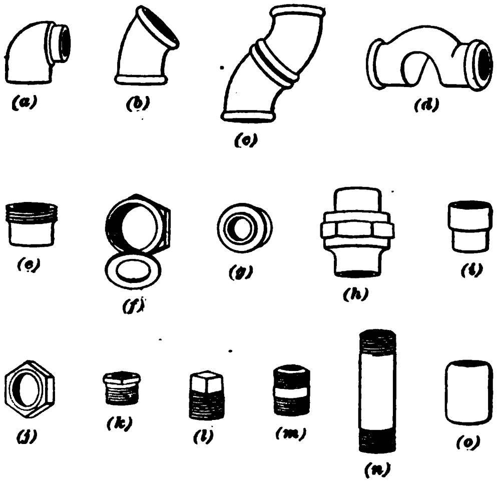


FIG. 20

In Fig. 20 (*e*), (*f*), and (*g*) are shown parts of a ¾-inch **plain union,** which is shown assembled in (*h*). Fig. 20 (*e*) shows the threaded half of the union, while (*g*) shows the half having a shoulder. The hexagonal **coupling ring** shown in (*f*) is slipped over the part shown in (*g*), and screws on the thread of the part shown in (*e*) when the two halves are put together. A rubber washer, shown beneath the coupling ring, which fits over the shoulder, is placed between the two halves and is compressed by screwing up the coupling ring, thus making a tight joint.

Fig. 20 (*i*) shows a ¾" × ½" **plain reducing socket,** used to reduce ¾-inch pipes to ½ inch on a straight run. A ¾-inch **hexagonal locknut** is shown in Fig. 20 (*j*); it is used for screwing over a long thread and making tight connections to a tank, one locknut being outside the tank, and one locknut inside, with gaskets between them and the sides of the tank; and for other work.

An illustration of a ¾" × ½" **bushing,** which has a hexagonal shoulder, is given in Fig. 20 (*k*). The male thread is ¾ inch and the female thread ½ inch, used to reduce a tapped opening so as to adapt it to fit a smaller pipe.

Fig. 20 (*l*) illustrates a ¾-inch **plug** that has a square head; it is used for closing a tapped opening. In Fig. 20 (*m*) is shown a ¾-inch **shoulder nipple,** which is a piece of straight pipe having a tapered thread on each end, with a short space between the threads; it is used for joining two fittings together at close quarters. A common ¾-inch **nipple,** which is only a little longer than the shoulder nipple, is shown in Fig. 20 (*n*).

Fig. 20 (*o*) shows a ¾-inch **plain coupling,** which is tapped in both openings, and is used for joining two ¾-inch pipes that are on a straight line.

61. Cast-iron fittings threaded for wrought-iron and steel pipes are generally used for steam-heating and hot-water heating systems. They are provided with especially heavy beads or bands, because cast iron is a much weaker metal than malleable iron when subject to tension, as is the case with the beads of fittings.

62. Unions are made in many forms. Their duty is to join together the ends of two pipes where it is not possible to turn either one, or in places where it may at some future time be desired to disconnect the pipes without cutting them.

63. There are two kinds of unions, the *flanged* and the *screwed*. The **flanged union,** shown in Fig. 21, is used principally on wrought-iron pipes having a diameter of 2 inches or more. The pipe ends *a*, *a* are screwed into the flanges *b* and *b*. The leather washer *c* is placed in position between the flanges, and then compressed by the nuts *d*, *d* being screwed up. This draws the flanges together and makes a water-tight joint. Care must be taken to have the nuts screwed up equal all around, so that the pressure upon the washer will be uniform.

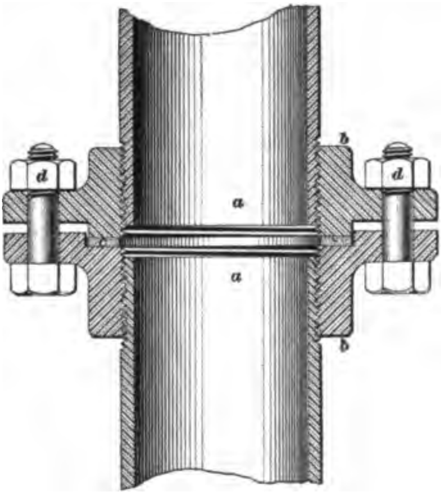


FIG. 21

64. The **screwed unions** are of two kinds, the *ground*, shown in Fig. 22, and the *packed*, which is shown in Fig. 20 (*e*), (*f*), (*g*), and (*h*). In the **ground unions,** the cone *a* and the socket *b* are ground to a perfect fit, and are drawn together by the nut *c*. The collar *d* must be

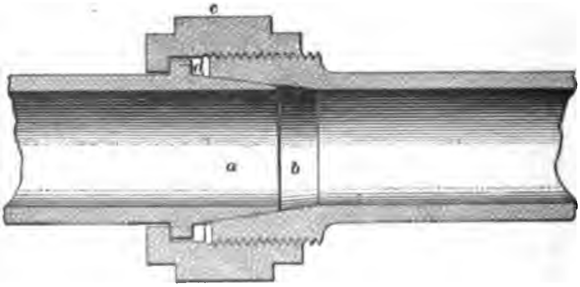


FIG. 22

turned true with the axis of the cone, and the axis of the screw thread must also coincide perfectly with that of the cone, otherwise it will be difficult to draw the joint together with sufficient accuracy to make a tight joint. The joint is made by the fit of the parts rather than by the pressure put upon them. Therefore, if the joint is not tight, do not attempt to make it so by straining the nut *c*, but rectify the fit of the parts.

SOIL-PIPE FITTINGS

65. Soil-pipe fittings are made of cast iron, and are either provided with spigot and socket ends for connecting to cast-iron pipe by means of calked joints, or they are provided with threaded ends for connecting the wrought-iron or steel drainage pipes by means of screwed joints. Common fittings that are kept in stock by plumbers' supply houses are shown in Figs. 23 to 26. The names printed under the fittings are their trade names. The abbreviation D. H. means double hub; R. H. means right hand; I. P. means iron pipe.

66. In Fig. 23, the quarter bend shown, which is more commonly called an **elbow,** makes a bend of 90° and is the fitting most commonly used. The elbow with side inlet receives a branch in the curved portion, but makes a connection inferior to that made by a **Y** branch. The quarter-bend heel outlet should only be used when the branch can be placed vertically on top. The long bend is rarely used. The one-fifth, one-sixth, one-eighth, and one-sixteenth bends are occasionally called **obtuse bends.** Bends are designated by a common fraction in which the numerator always is 1, and the denominator shows the number of bends that, when placed together, form a complete circle. Thus, 4 one-quarter bends, or 6 one-sixth bends, joined together complete the circle. The one-eighth bend is the most commonly used obtuse bend. The tee and long tee are useful for vent branches, but should not be used for pipes conveying liquid waste matter. The sanitary **T Y** is a fitting which is half **T**

and half **Y**; it often proves very useful in drainage work. It requires less space than a **Y** fitting, but the latter is superior from the sanitary standpoint. The sanitary **T Y** with side inlet has a 2- or 3-inch socket, to which a bath or basin waste pipe may be connected, while the larger branch takes the water-closet waste pipe. The one-half **Y** branch is rarely used. In the **Y** branch, the branch makes an angle of 45° with the run. It is one of the best branch connections. The **Y** side inlet is used for the same purpose as the sanitary **T Y**, but is superior to it from the sanitary standpoint.

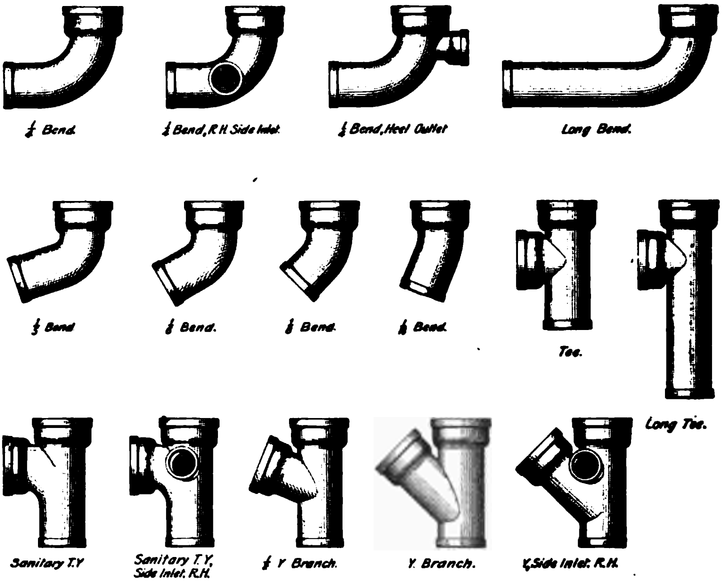


FIG. 23

67. In Fig. 24, the long **Y** branch shown is used for the same purpose as the **Y** branch illustrated in Fig. 23. The cross is one of the most undesirable fittings and should never be used. The double sanitary **T Y**, the double one-half **Y**, and the double **Y** have two branches located opposite each other, as in the cross, but are far superior fittings, the double **Y**

being the best. The inverted **Y** is used in vent pipes (where the direction of the current is *upwards*) for receiving a vent branch. The ventilating branch serves the same purpose as the inverted **Y**, but its lower end is more easily made tight by calking. The return bend is used on top of fresh-air inlet pipes, or ventilating pipes, to prevent the admission of foreign matter to the drainage system. The offset is often needed to offset a soil pipe at the top of the cellar wall of

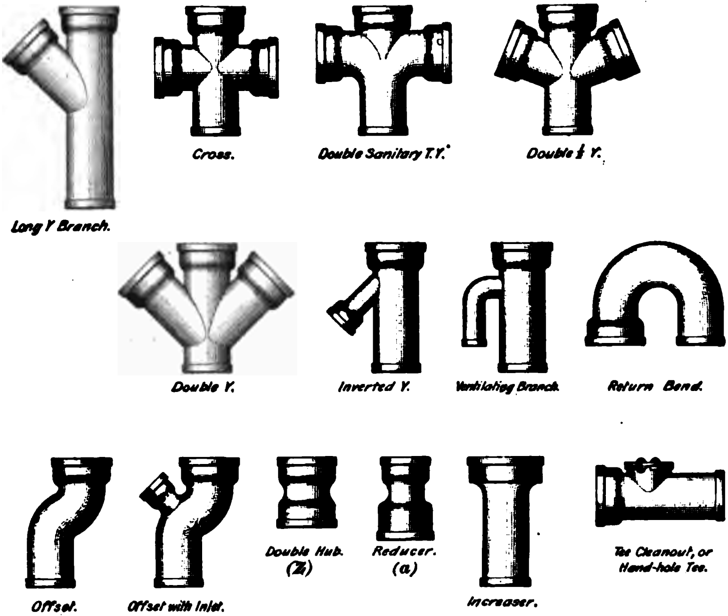


FIG. 24

frame buildings. The offset with inlet is used for the same purpose as the offset; it has a 2-inch socket to receive the waste branch from a sink, etc. The double hub is used for joining two pieces of pipe having no socket; it is never employed in good work. The reducer is often used in underground drainage work for reducing to a smaller size pipe. The increaser is used for increasing, and is often employed on soil pipes where they pass through the roof.

The tee clean-out, or handhole **T**, permits the line of pipe to which it is attached to be cleaned out. It should never be used inside of a building, since the joint between the cap and fitting is liable to leak sewer gas, as it is intended to be made with putty.

68. The sleeve shown in Fig. 25 is used to join the ends of two pieces of pipe that come together without a socket, as happens when a drain pipe is cut that a branch may be placed in it. The thimble and cover is calked into a socket of a drain pipe to give admittance to the latter for cleaning out, but should never be used inside of a building. The thimble, or bushing, is placed into a socket to reduce its size. Ventilator caps are placed on the ends of fresh-air inlets and ventilating stacks to keep out foreign matter.

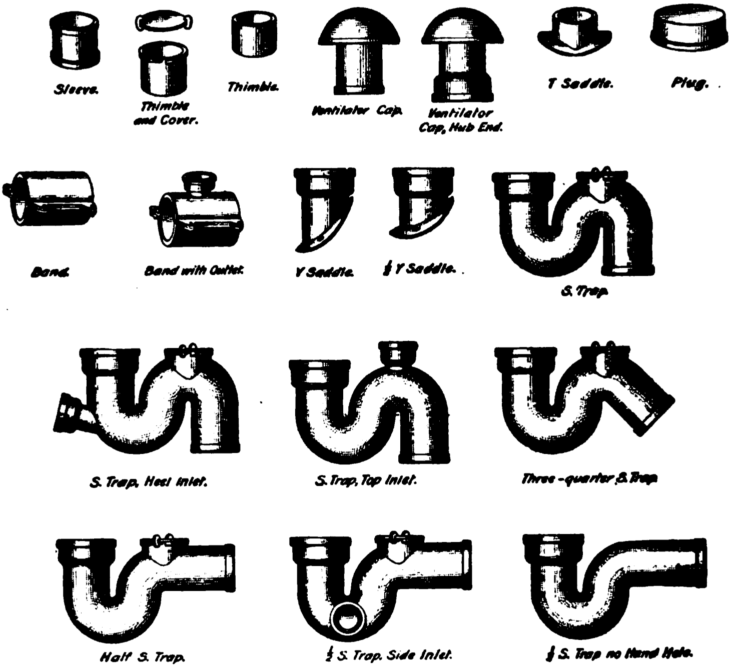

Sleeve.
Thimble and Cover.
Thimble.
Ventilator Cap.
Ventilator Cap, Hub End.
T Saddle.
Plug.
Band.
Band with Outlet.
Y Saddle.
½ Y Saddle.
S. Trap.
S. Trap, Heel Inlet.
S. Trap, Top Inlet.
Three-quarter S. Trap.
Half S. Trap.
½ S. Trap, Side Inlet.
½ S. Trap no Hand Hole.

FIG. 25

The **T** saddle is placed over a hole cut into a drain pipe to receive a branch. As the joint is made with putty, it should never be used inside a building. The plug is used for closing the end of a pipe. The band is used for repairing a broken pipe or closing up a hole in it. The band with saddle, the **Y** saddle, and the one-half **Y** saddle are used for making branch connections, but should never be used inside of buildings, as the joint between them and the pipe to which they are attached does not remain gas-tight. The **S** trap, the **S** trap with heel inlet, the three-quarter **S** trap, and the one-half **S** trap with side inlet here shown have a cleaning cap. As the joint between the cap and trap, which is made with putty, does not remain gas-tight, these traps should not be used inside buildings. The **S** trap with top inlet and the one-half **S** trap without the handhole here shown have no putty joints about them, and are hence suitable for use inside buildings.

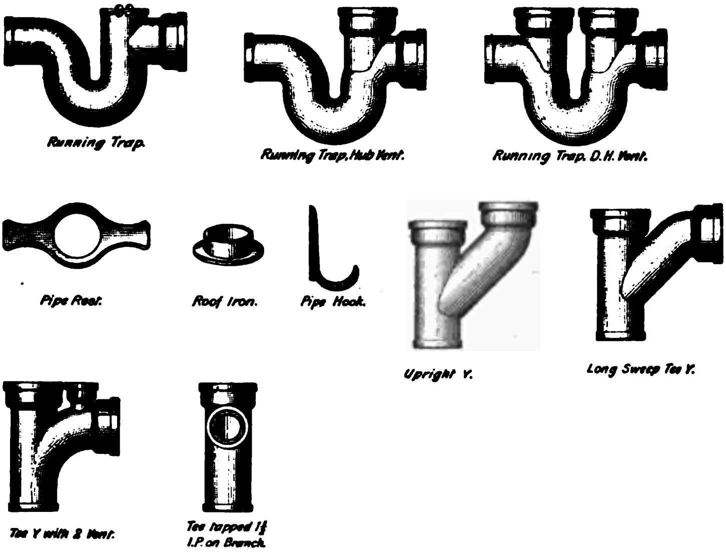

Running Trap.
Running Trap, Hub Vent.
Running Trap. D.H. Vent.
Pipe Rest.
Roof Iron.
Pipe Hook.
Upright Y.
Long Sweep Tee Y.
Tee Y with 2 Vent.
Tee tapped 1½ I.P. on Branch.

FIG. 26

69. The running trap shown in Fig. 26 has a clean-out inlet and is suitable only for outdoor work. The running traps with hub vent and double-hub vent are suitable for inside work, the trap with double-hub vent being the most sanitary. The pipe rest is used to support pipes in a brick wall. The roof iron serves to make a neat joint where the soil pipe passes through the roof. The pipe hook is used to support soil pipes running along walls. The upright **Y**, long sweep **T Y**, **T Y** with vent, and **T** tapped for iron pipe in the branch are fittings especially made to conform to the specifications of modern plumbing codes.

70. Malleable-iron drainage fittings, in a general way, are similar in form to those made of cast iron, but the ends, instead of having a spigot and socket, are provided with threaded sockets into which the iron pipe is screwed. The ordinary pipe fittings used in steam fitting have a larger internal diameter than the pipes that are attached to them, as is shown in Fig. 27; on account of the pocket thus formed, they are suitable only for vent-pipe work, but not for drainage work. The bands *a*, *a* around the sockets strengthen the fitting against the bursting strain that arises from the screwing of the pipes *b*, *b* into the sockets.

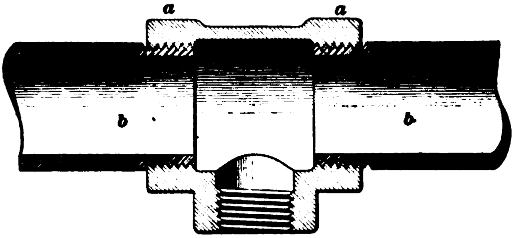


FIG. 27

71. Drainage fittings must be free from pockets when connected up; for this reason their internal diameter is made the same as that of the pipes to which they are attached, and in order that there may be very little space between the end of the pipe and the shoulder at the inner end of the socket, it is necessary to so regulate the dies that each thread will be cut just so long that when the pipe is screwed up tight, the end will almost, but not quite, butt against the shoulder of the fitting, as shown in Fig. 28. These fittings can be had in all sizes, and are made either of cast iron or malleable iron.

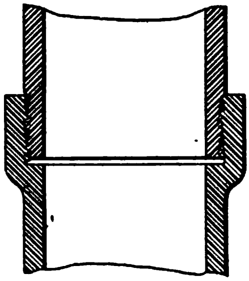


FIG. 28

72. Fig. 29 illustrates how connections are made with malleable-iron fittings and wrought-iron pipe. It will be observed that the interior surface of the fittings is *flush* with that of the pipe; from this fact the name **flush fittings** is derived.

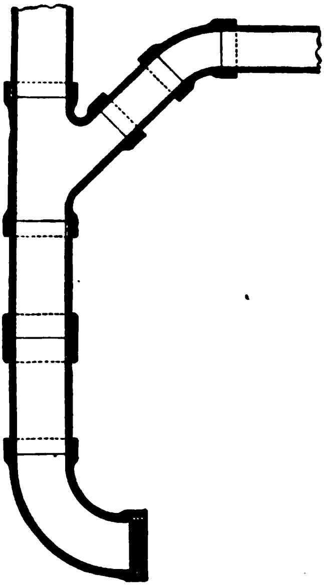


FIG. 29

73. Earthenware pipe fittings are made chiefly in the forms of bends, branches, and traps, and are very similar in appearance to the cast-iron drainage fittings. In order to obtain a good earthenware pipe drain, it is necessary to carefully select the fittings, for many of them are defective.

SPECIAL FITTINGS

74. Straddle Fittings. Fig. 30 shows **straddle fittings** *a*, *a* screwed in place. They are commonly used in places where two water pipes that are quite close together have branches that must cross the main lines. They are simply elongated tees, so constructed that the branch arm of each one will snugly and neatly *straddle*, or cross over the adjoining pipe, as shown. One of these fittings accomplishes the same object as five of the ordinary fittings, thus saving considerable labor and material.

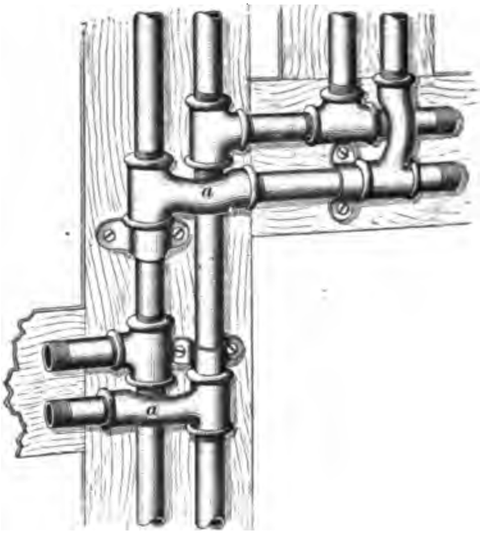


FIG. 30

75. Laundry-Tub Supply Connection.—To avoid the hot and cold supply pipes at the back of a set of laundry tubs forming traps between the faucets, and thus becoming liable to freeze and burst when the water is shut off and the pipes supposed to be drained empty, the special fitting shown in Fig. 31 has become quite popular. The faucets inside the tubs of course must be in line, which prevents the two pipes from being run level with and immediately back of the faucets.

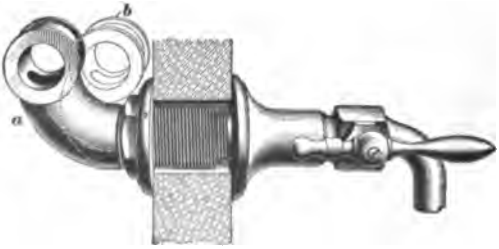


FIG. 31

With this special fitting, however, the pipes are located above the line of the faucets and are run straight, so that they may be drained empty when the water is shut off. This fitting is particularly valuable in country homes that are not occupied during the winter, for it prevents frost bursts at the back of the wash tubs.

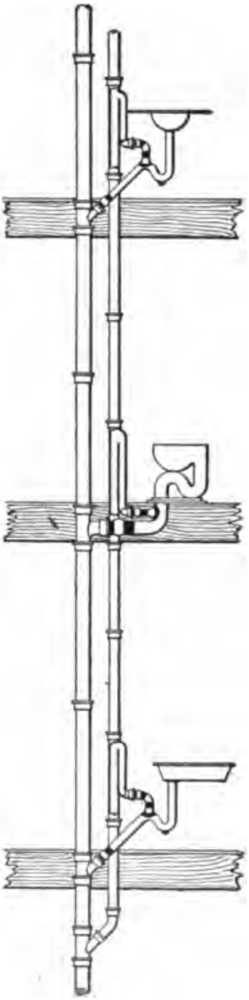


FIG. 33

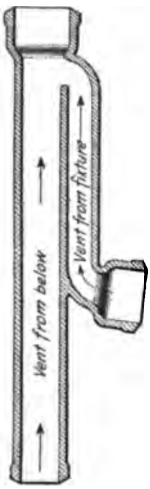


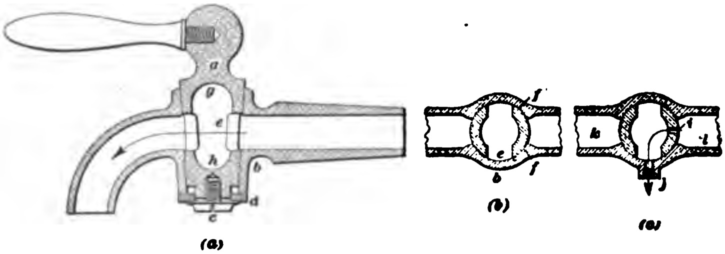
FIG. 32

76. Back-Vent Fitting.—A special fitting for back-venting plumbing fixtures is shown in Fig. 32. It is really a part of the vent stack and a back-vent branch combined in one casting. The vent branch is dropped down and a socket is cast on its lower end, for connecting to the back-vent pipe of the fixture. The object of this fitting is to avoid a multiplicity of calked joints, and at the same time prevent waste water from backing up and flowing into the vent stack, if the waste pipe should become choked. These fittings are especially adapted for use on vent stacks in recesses and other places where there is but little space; they form a neat, compact, and durable method of connection. Fig. 33 shows the back-vent pipes for the traps of several fixtures connected to a vent stack by means of special vent fittings. These fittings are made in different shapes and sizes, and with single- or double-drop branches.

COCKS, VALVES, AND SUNDRIES

COCKS

77. Plug Cocks.—In Fig. 34, the construction of an ordinary **plug cock,** also called a **ground-key cock,** is shown. The plug *a*, Fig. 34 (*a*), is turned truly circular, and is also tapered to fit the conical socket *b*, which is bored or reamed in the body of the cock. Formerly the plug and socket were fitted to each other by grinding with emery, and they thus became known as *ground-key cocks.* The plug is held in place by means of a screw *c* and the washer *d.* The washer fits over a squared shoulder on the small end of the plug, so that they turn together, as otherwise the screw would loosen itself every time the plug was turned. The waterway through the plug consists of a rectangular slot *e*; the corresponding openings in the side of the socket should also be rectangular and of the same width. The tightness of the cock will depend on the perfection of the fit of the plug and socket at the points *f*, *f*, Fig. 34 (*b*). If these surfaces are narrow, the cock will soon wear and become leaky.



(a) (b) (c)

FIG. 34

The plug being of larger diameter at the top edge of the slot than at its lower edge, it follows that there is a difference of area between the top and bottom of the slot; consequently, the pressure of the water within the pipes tends to drive the plug out of the socket. Thus, if the area of the bottom surface of the slot were 1 square inch and that of the top surface of the same were 1⅛ inches, the difference in area would be ⅛ square inch. Suppose the water pressure is 100 pounds per square inch; there is then a pressure of 100 pounds upon the bottom of the slot tending to hold the plug in place, and a pressure of 112½ pounds upon the upper end of the slot, tending to drive the plug out of the socket. Thus, there would be an unbalanced pressure of 12½ pounds tending to lift the plug, and which must be resisted by the screw *c*. This is a matter of small account in common sizes, but in large cocks it becomes a matter of importance.

Some manufacturers core out the body of the plug, as shown at *g* and *h*, to economize metal. Cocks having these cavities should not be used, if possible, because they greatly obstruct the flow of water. The best kind of plug cock is that in which the waterway through the plug is round. This prevents unnecessary resistance to the flow of the water.

Plug cocks are either constructed with a handle, as shown in Fig. 34, or the top of the plug is shaped to receive a wrench.

78. Stop-and-waste cocks are a kind of plug cocks having a small hole *i*, Fig. 34 (*c*), drilled through the side of the plug and another through the side of the socket at *j*.

The plug of the ordinary ground cock can be given a complete turn, but the plug of the waste cock can only be given a quarter-turn, the rotation being limited by a pin attached to and projecting from the plug, and moving in a groove cut in the top of the socket.

The groove only occupies the space of one-fourth of the circumference, and as the plug cannot travel farther than the pin, the cock must be open when the handle is in one position and closed when in the other.

Care must be taken when placing stop-and-waste cocks upon a system that the draining hole *i*, Fig. 34 (*c*), is on the proper side. For instance, in placing a stop-and-waste cock on a branch from a street main for the purpose of shutting off water from a building, the cock must be so attached that when shut the opening *i* will be towards the building, so that the pipes therein may be drained at that point. The end *k* of the stop-and-waste cock would be connected to the main, and *l* to the house pipes.

79. Three-way cocks are constructed as shown in Fig. 35. The key, or plug, *a* has a three-way channel *b* passing through it, which can be made to communicate with the openings *c*, *d*, and *e* for the pipe connections. By turning the key, or plug *a*, communication can be made between *c* and *d*, while *e* is shut off; between *d* and *e* while *c* is shut off; between *c* and *e* while *d* is shut off; or they may all be open to one another, as shown in the illustration.

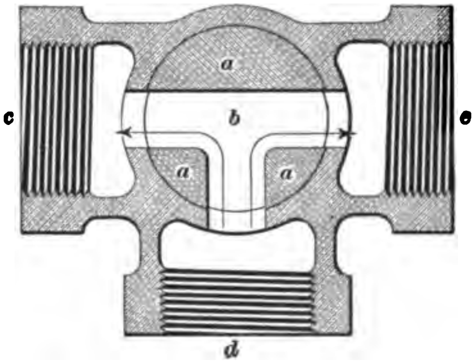


FIG. 35

80. Swing cocks, one of which is shown in Fig. 36, are a special type of plug cock. The plug *a* is stationary and receives the water through the lower end. The socket *b* is provided with a suitable nozzle or discharge *c*, and can be turned on the plug.

The waterway is opened or closed by swinging the nozzle. The form of swing cock shown is called a **basin swing cock.** It is attached to the basin top in such a manner that when the nozzle *c* points toward the center of the basin, the cock will be open, and when tangential to the circumference of the basin the cock will be closed.

81. Fig. 37 (*a*) shows a **common lever-handle ground-key plain sink bibb** for lead pipe. This has a plain tail *a*, which is intended to be soldered to a lead supply pipe. It is called a plain bibb because the nose *b* is plain. Fig. 37 (*b*) shows a **ground-key lever-handle sink hose bibb** for iron pipe. The nose is threaded to fit a common ¾-inch garden-hose coupling, and the tail is threaded to screw into an iron-pipe fitting. Fig. 37 (*c*) shows a **plain lever-handle stop-cock** for lead pipe. A stop-cock is always closed when the handle points across the pipe. Fig. 37 (*d*) shows a **plain ground-key wash tray or tub bibb** for lead pipe. It is closed when the handle *a* points down. Fig. 37 (*e*) shows a **lever-handle stop-and-waste cock** threaded for iron and having a waste tube *a*. When the stop-cocks are buried in the ground and have to be operated by a rod, a **socket head** is attached to the plug instead of a lever handle. The rod is slipped into the socket and secured there by a setscrew; or, a crosshead may be cast on the plug, a rod and socket being used to turn the key. Fig. 37 (*f*) shows a **three-way ground**

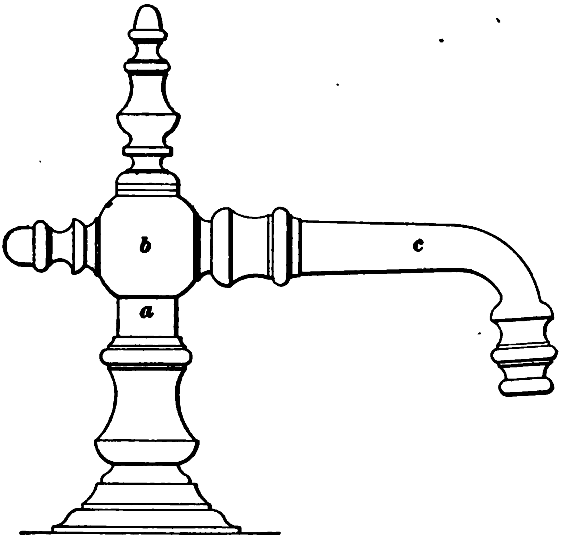


FIG. 36

cock for lead pipe. The barrel is large, which shows that the waterways in the plug are round. This is often used on the suction pipe of a pump that raises water from a well or cistern. The pump is connected to *a*, while *b* and *c* connect to the well and cistern, respectively.

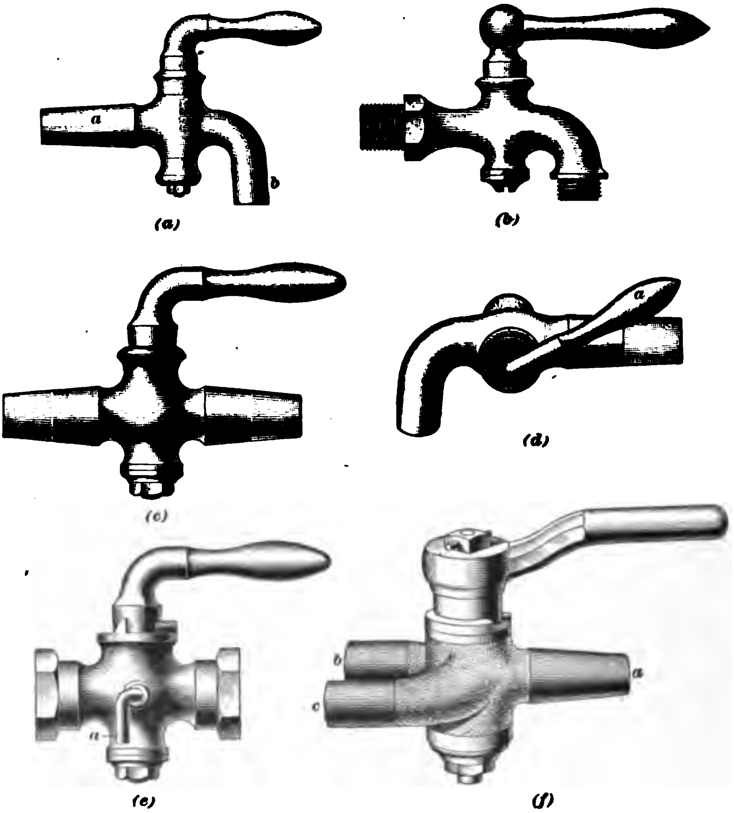


FIG. 37

82. Fig. 38 shows a **corporation cock** and ring coupling. The end *a* is threaded to screw into an ordinary cast-iron street water main. The barrel around the key is made extra heavy and is flattened on each side to fit the jaws of a certain make of tapping machine. After the coupling *b* is soldered to the lead service pipe that supplies water to the building, the coupling ring *c* is screwed on to the cock, a ground joint being used to make the coupling water-tight.

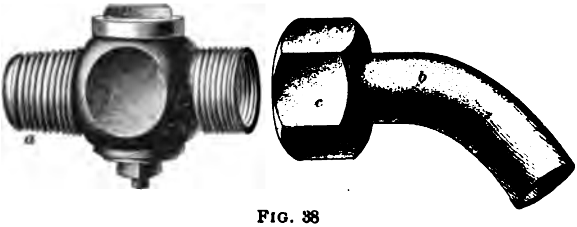


FIG. 38

83. Regrinding Leaky Plug Cocks.—When a ground plug cock begins to leak, it is usually cheaper to replace it with a new one. If this cannot be done, it is customary to *grind it;* that is, to grind down irregularities existing between the external surface of the plug and the internal surface of its socket, so that these surfaces will be in equal contact throughout their area and thus prevent water from passing between them. The grinding process may be done as follows: Take out the plug of the cock and examine it for the part that does not come in contact with the socket. This part will be dark in color and the bearing parts bright and polished. Then sprinkle fine emery or powdered bath brick on the polished parts and insert the plug in its socket. Next, with the hand, partly turn the plug first to the right and then to the left, pulling it out a little and pushing in again at the points where the motion is reversed. The turning motion will grind down the prominent parts of the plug and socket and the pulling-out and pushing-in motion, although slight, will cause a uniform film of grinding material between the surfaces. The plug should be occasionally dipped in water and resprinkled with emery.

84. Compression Cocks.—Plug cocks are well adapted for situations where it is not necessary to turn the water on or off frequently, but when used where they must be moved very often, they give considerable trouble by leaking. For such service, **compression cocks,** also called **bibbs,** are much superior. A common construction is shown in Fig. 39. The water passes through the orifice *a*, which is closed by means of the valve disk *b*. This disk is made of some elastic material and is held in a block *c*, which is attached by a swivel joint to the end of the screwed stem *d*. If the block *c* is allowed to turn with the screw, the disk *b* will soon be injured and become leaky. The water is prevented from flowing out around the top of the stem *d* by placing lampwick or other suitable packing in *e*, which is pressed against the stem by screwing down the nut *f* on the bonnet *g*.

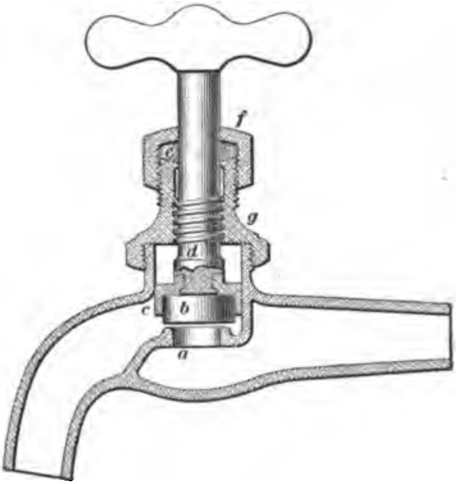


FIG. 39

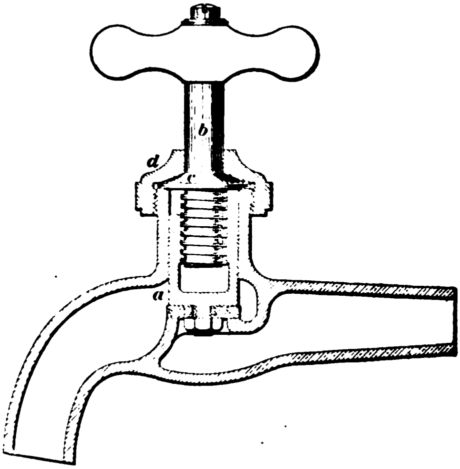


FIG. 40

85. Compression cocks are also constructed in other ways, one of which is shown in Fig. 40. The block *a* is prolonged upwards and constitutes a nut that receives the screw thread of the stem *b*. The stem is provided with a solid collar *c*, which bears against the cap *d*, the joint being ground. Thus, the spindle does not rise as the valve opens.

The block *a* is made either square or round. When round, it has two lugs placed diametrically opposite each other, which, upon turning the stem, slide up or down in grooves provided for them in the casting of the cock. This is done to prevent *a* from turning.

86. A **rapid-closing compression cock,** known to plumbers as the **Fuller cock,** is shown in Fig. 41. The lower end of the stem *a* is offset and forms a crank *b* of sufficient radius to move the valve *c* to and from its seat. A half turn of the handle will open the valve to its full extent, and the other half turn will close it. The handle may be turned in either direction.

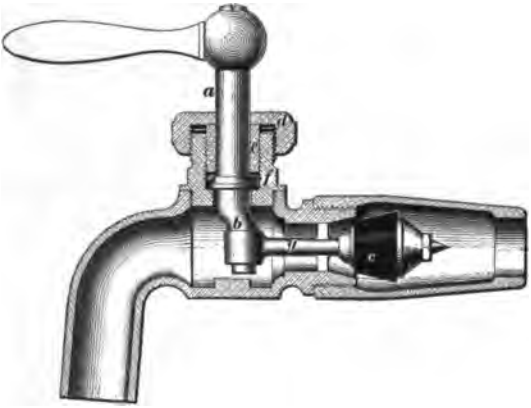


FIG. 41

In this form of cock the water pressure is on the back of the soft conical rubber valve *c*, and pushes the valve against its seat. The stem is made water-tight by screwing down the nut or cap *d*, which forces down the bushing *e*, and thereby compresses the packing at *f* around the stem. The valve is guided to its seat by prongs cast on the stem *g*, to which the valve *c* is fastened. These cocks are used chiefly on low-pressure work where the water is free from grit, etc.

87. Fig. 42 (*a*) shows a common **compression plain bibb with cast flange, threaded for iron pipe.** This is used chiefly where the supply pipe comes through the wall, or through a slab at the back of a sink. In Fig. 42 (*b*) is shown a **compression hose bibb with stuffingbox,** having a cast flange, bent coupling, and locknut attachment. This is used where the supply pipe comes up back of a slate or marble slab. The locknut *a* at the back of the slab *b* when screwed up tightly makes the cock rigid. The tail of the coupling is intended to be soldered to lead pipe. Fig. 42 (*c*) shows a **plain sink Fuller bibb with cast flange,** threaded for iron pipe. It is intended to be screwed into the socket of a fitting that is located flush with the wall, or back slab of a sink. Fig. 42 (*d*) shows a solid flange **Fuller tub cock** threaded for iron pipe. This cock is closed when the handle points down.

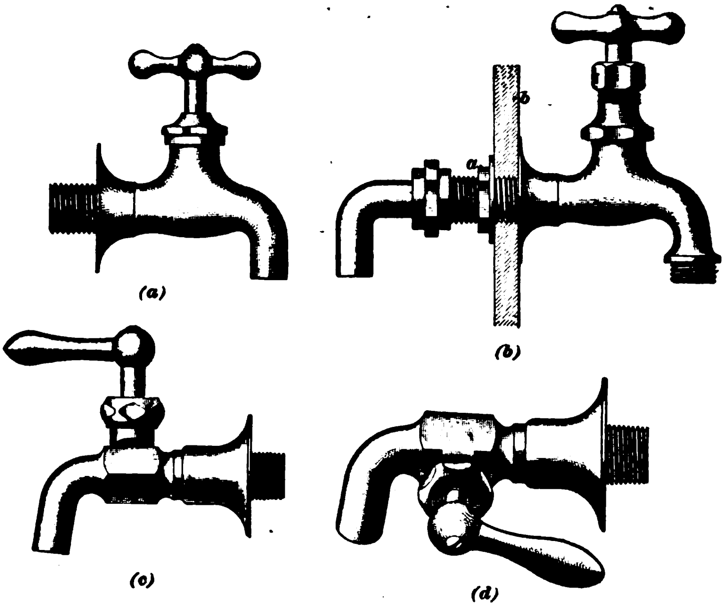
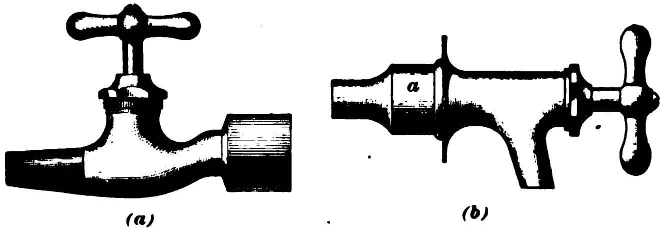


FIG. 42

88. Fig. 43 (*a*) shows a common **compression urinal cock**; the inlet end is shown plain for soldering to a lead water pipe. The other end has a socket that fits over the urinal horn. Fig. 43 (*b*) shows a **compression tub cock with flange and thimble.** The thimble *a* is intended to be soldered to a lead pipe.



(a)
(b)

FIG. 43

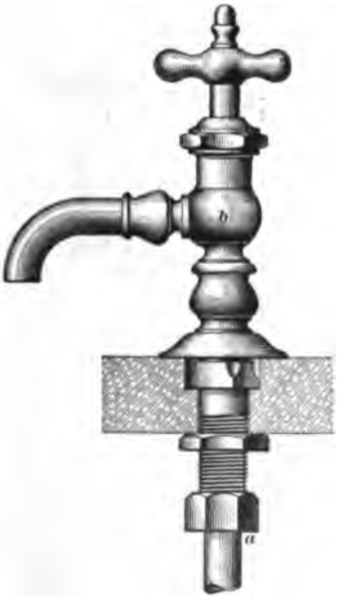


FIG. 44

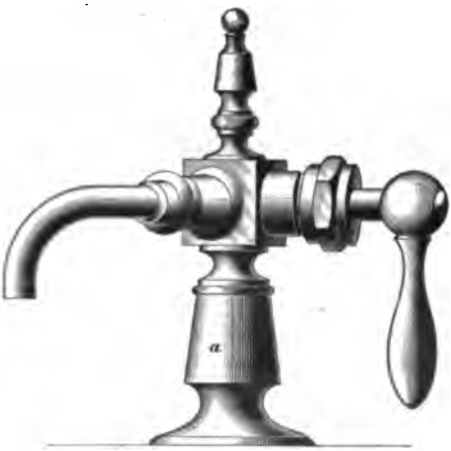


FIG. 45

89. Fig. 44 shows a **common compression basin cock** with locknut attachment to a marble basin slab, and a coupling *a* for lead pipe. This is the kind most commonly used on ordinary wash basins. The valve seat is located at *b*. Fig. 45 shows a **Fuller basin cock** intended to be set on the marble slab of a wash basin. The valve seat is located at *a*. The valve should be closed when the handle is down. It should be attached to the slab in the same manner as the cock shown in Fig. 44.

90. Fig. 46 shows a **compression pantry sink cock.** This is the kind in common use on ordinary butler's pantry sinks. It is simply a globe valve fitted with a long **swan-neck** discharge tube on top and a flange and locknut attachment below. These cocks can be had with ground keys. Fig. 47 shows a **compression combination bath cock.** The valve seats are located at *a* and *b*. Both valves discharge into the outlet *c*. This cock is provided with locknut attachments on both hot and cold connections to secure it to the foot of a bath.

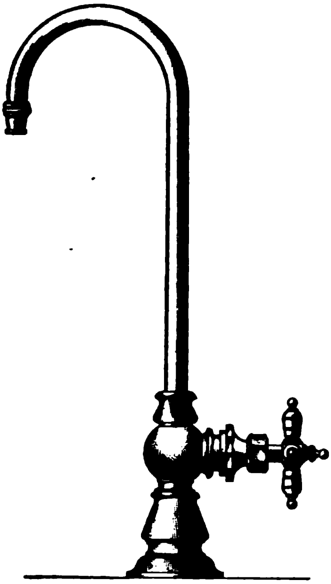


FIG. 46

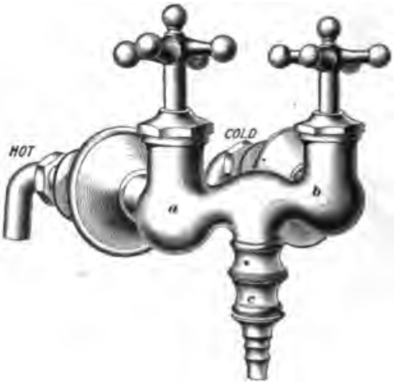


FIG. 47

91. Self-closing compression cocks differ from the common kind in having a stout coiled spring under the cap, or some other contrivance, to close the valve, instead of the usual screw and handle. The handle is always a lever of some kind, which is so arranged that the valve may be opened by it, but as soon as it is released the spring, or other contrivance, automatically closes the valve.

The chief objection to the self-closing or spring cocks is that they close too suddenly, and cause a shock upon the pipe system. The nature of the shock is similar to that received by a hydraulic ram when the large valve is suddenly closed. The best self-closing cocks, therefore, are those that close slowly. Self-closing cocks are only used where water is scarce, so that none may be wasted by careless persons leaving the cocks open.

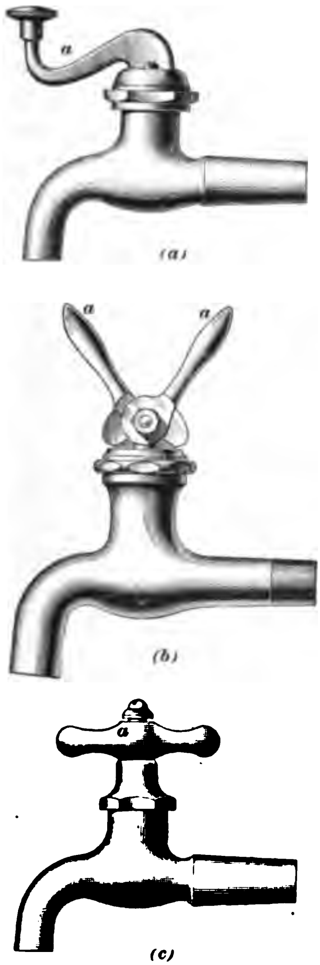


FIG. 48

92. Fig. 48 (*a*) shows a **single-lever plain spring sink bibb** for lead pipe. The cock opens by pressing down on the lever handle *a*, and closes by the force of a spring when the pressure is removed. Fig. 48 (*b*) shows a **plain rabbit-ear spring sink bibb** for lead pipe. By squeezing the **ears**, or levers, *a*, *a* together the valve is opened against a strong spring, but it instantly closes when the ears are released. In Fig. 48 (*c*) a **crosshead spring plain sink bibb** for lead pipe is shown. By turning the crosshead *a*, the valve is raised against the force of a strong spring, which automatically closes the valve when the crosshead is released.

93. A common form of **ball cock,** which is chiefly used for supplying water to tanks, is shown in Fig. 49. The body *a* is bored to receive the cylindrical stem *b*, to which the valve *c* is attached. The water enters through the pipe *d* and escapes through *e*. A cup leather *f* is secured between *b* and *c*, which prevents water from passing the guide stem *b*. The ball *g* is hollow and its buoyancy in water is utilized to close the valve. It is attached to the lever *h*, the short end of which engages the stem *b* of the valve. As the water rises in the tank to which this valve is attached, the ball floats upwards and gradually pushes the valve to its seat and stops the inflow of water.

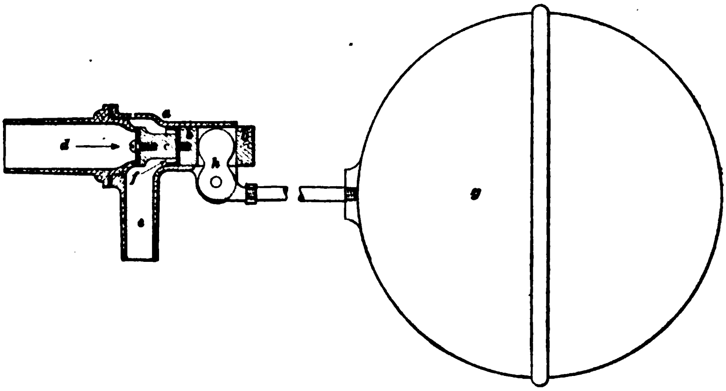


FIG. 49

When the water in the tank is discharged, *g* drops and thereby opens the valve *c*, which permits water to flow into the tank.

The hollow ball *g*, although carefully made, will sometimes partly fill with water. This causes the ball to sink and allows the water to run and overflow the tank.

VALVES

94. Globe Valves and Gate Valves.—The ordinary **globe valve** shown in Fig. 50 and the **angle valve** shown in Fig. 51 belong to the compression class. The waterway through a globe valve is so contorted that the flow of water is obstructed to a serious degree.

Globe valves should be attached to the pipe system in such a manner that the valve will close against the pressure, as otherwise when the valve is on its seat the water will work up along the valve stem and leak. The same applies to the angle valve. The ordinary globe valve is used on straight pipe, while the angle valve is used at the junction of two pipes at right angles.

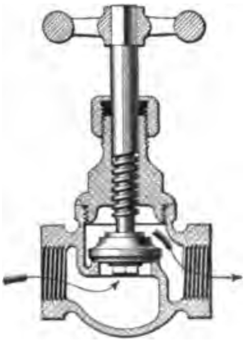


FIG. 50

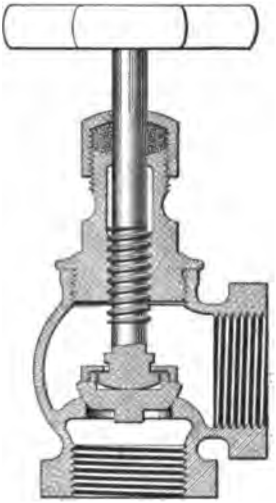


FIG. 51

95. The **gate valve** shown in Fig. 52 serves the same purpose as the globe valve, but furnishes a freer passageway for the water. By turning the stem *a*, the wedge-shaped disks *b* and *c* are moved across the seats *d*, *d* and the orifice is opened or closed gradually. The disk *c* has cast on its lower side a projection *e*, which rests on a corresponding projection *f* cast to the valve body. These projections prevent the disk *c* from moving down too far. The disks are wedged apart and pressed tightly against their seats by turning the stem *a* in the proper direction.

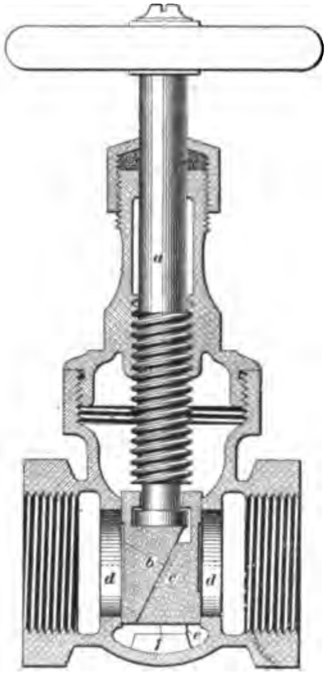


FIG. 52

Gate valves are made quick acting by substituting a lever and sliding stem for the screw stem shown.

96. Check-Valves.—A form of valve that permits the flow of a fluid in one direction only and positively prevents a reversal of the flow is called a **check-valve.** There are two kinds of check-valves in common use—the *globe check* and the *swing check.*

97. The **globe check** is shown in Fig. 53. The valve *a* is a solid disk of metal having a beveled edge to suit the seat *b*, and is guided by the wings *c*, *d*, as shown. The fluid passes in the direction of the arrows. A cap *e* gives access to the valve.

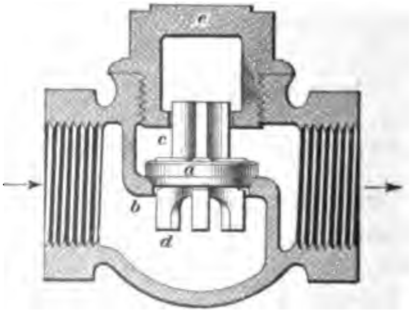


FIG. 53

98. An improved form of check, known as a **swing check,** is shown in Fig. 54. The valve disk *a* is attached to an arm that swings on a pin, as shown. The passage of fluid through this valve is more direct than in the globe check, and the pressure required to open the valve is much less. The fluid passes through the valve as shown by the arrows, that is, from *b* toward *c*. In case of a rapid flow of water, the projection *d* on the end of the arm to which the valve is attached strikes against the bottom of the screw *e*, and is thus prevented from going too far.

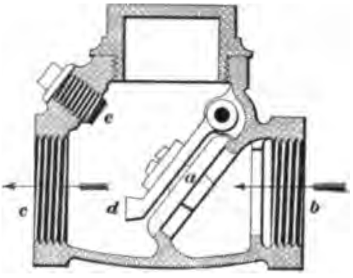


FIG. 54

99. A check-valve especially adapted for drainage purposes, and called a **back-water valve,** is shown in Fig. 55. It is used to prevent water in the street sewers from backing up into the house drains, as is liable to occur during a heavy rainfall if the sewers are too small or have too little fall. This valve should never be used on a system of house drainage unless it is absolutely impossible to avoid it, as it is liable to cause a chokage in the house drains by allowing the liquids to pass, and retaining the solids. This is likely to happen if the house drains have little fall toward the valve.

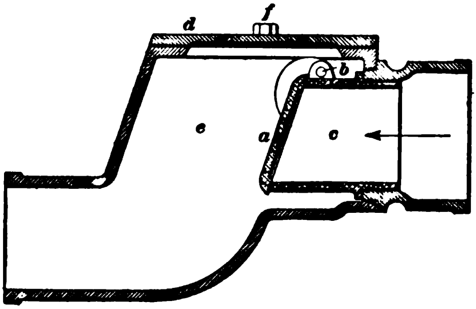


FIG. 55

Referring to the figure, it will be seen that the valve *a* swings on a pin *b*; the inlet is indicated by the arrow.

The valve and its seat *c* should be made of brass, so as not to corrode. For facilitating the cleaning out of the valve, a handhole and cover *d* are provided in the body *e*; the cover is held in place by bolts *f* on each side of it. To prevent leakage, packing should be placed under the cover.

100. Another form of a back-water valve is shown in Fig. 56. This is used chiefly to drain water from the basement floors, etc., where there is danger of water backing up from the sewers. The valve is composed of a hollow copper float *a*, encircled by a soft-rubber ring *b*. A rest, or stop, *c*, for the float is attached to the brass valve seat *d* by four arms. These arms also act as guides to lead the valve to its seat when the sewage water rises in the drain pipe *e* and buoys up the valve. When the water falls in *e*, the float will fall from its seat and descend with the receding water until it reaches its stop, as shown, when it will be again open for surface water. A bell-shaped casting *f* suspended from the perforated cover *g* dips into water and forms a seal to prevent drain air from entering the building. This form of check-valve is commonly called a **back-water trap.**

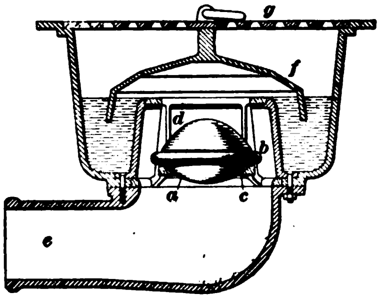


FIG. 56

101. Safety Valves.—A certain kind of valve is designed to open when the pressure within the vessel to which it is attached becomes greater than that for which the valve is set; it then permits the fluid to escape until the excess of pressure is relieved, when it closes. Such a valve is known as a **safety valve.**

102. One form of safety valve in common use for plumbing work is the **lever safety valve,** shown in Fig. 57. The valve *a* is held down on its seat against the upward pressure acting on the bottom of it by a lever *b* and weight *c*. Instead of holding down the valve in this manner, it is held down sometimes by means of a weight placed directly on the valve stem *d*, and is then known as a **dead-weight safety**

valve, or by means of a strong spring acting on the valve stem, and is then known as a **spring,** or **pop, safety valve.**

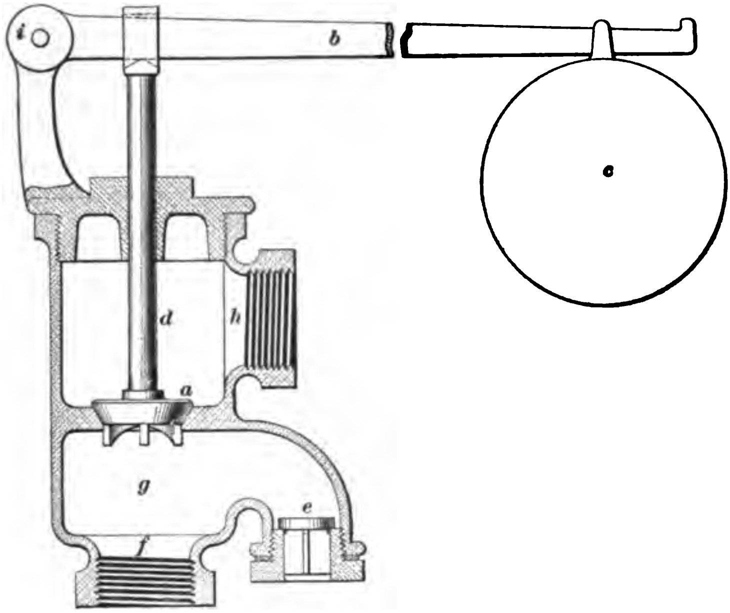


FIG. 57

103. Vacuum valves are similar to safety valves, except that they operate in the reverse way, the internal pressure acting upon the top of the valve and the external, or atmospheric, pressure acting on the under side. Thus, if a vacuum is being formed within a boiler, so that there is danger of its collapsing from the external pressure of the atmosphere, the valve will open and will allow enough air to enter to destroy the vacuum. Safety valves and vacuum valves for plumbers' use are commonly combined in one structure. Such an arrangement is shown by Fig. 57, in which *e* is the vacuum valve.

104. The action of the lever safety valve and the vacuum valve is as follows: Suppose the nozzle *f* to be attached to a vessel under pressure, so that communication is made between the vessel and the chamber *g*. Then the fluid contained in *g*, being under pressure, tends to raise the valve *a* off its seat and force the valve *e* downwards to its seat. When the pressure of the fluid per square inch in *g* multiplied by the area of the bottom of the valve *a* is greater than the weight of the valve *a* and stem *d* plus the force due to the weight *c* and lever *b* acting on the valve seat, the valve *a* will rise and the fluid will pass out of *h* into the atmosphere. After the pressure of the fluid in *g* and in the vessel has fallen a pound or so below that required to raise the valve *a* off its seat, the valve will again close.

Should the pressure in the vessel to which the safety valve is attached become less than that of the atmosphere, a partial vacuum would exist in the chamber *g*, and the atmospheric pressure would force upwards the valve *e* and thereby open it to admit air, which will destroy the vacuum and prevent the vessel from collapsing.

The pressure at which a lever safety valve will blow off depends on the weight of *c* and on the distance it is placed on the lever *b* from the fulcrum *i*. The nearer it is placed to the fulcrum, the less will be the blow-off pressure; and the farther it is placed from the fulcrum, the higher will the pressure rise before the valve will blow off.

The lever of lever safety valves should be periodically raised by the hand, as the valve is liable to stick to its seat.

105. Pressure-Reducing Valves.—In order to decrease the pressure of a fluid, a device known as a **pressure-reducing valve** is employed. Such valves are made for reducing the pressure of gases or liquids; the form used for reducing the pressure of liquids will be considered here. They are chiefly used in cities where the street water pressure is too great for the plumbing systems in the buildings to safely withstand. Their duty is to reduce the pressure within the building to a safe and suitable point.

Pressure-reducing valves are generally attached to the pipes that supply the buildings from the street mains whose pressures are to be reduced, and are usually located in the cellars of the buildings.

106. One form of a water-pressure-reducing valve is shown in Fig. 58. The water having high pressure enters at *a* and passes up the tube *b*. The orifice of this tube is closed by a flexible disk, or diaphragm, *c*, which is held down by a plunger *d*. When the pressure on top of *d* is diminished, the water lifts *c* and escapes over into the pipe *e*. The water in *e* also fills the chamber *f*, which is closed by the flexible diaphragm *g*. The plunger *h* rests upon the top of the diaphragm *g*, and its motion is transmitted by means of the lever *i* to the plunger *d*.

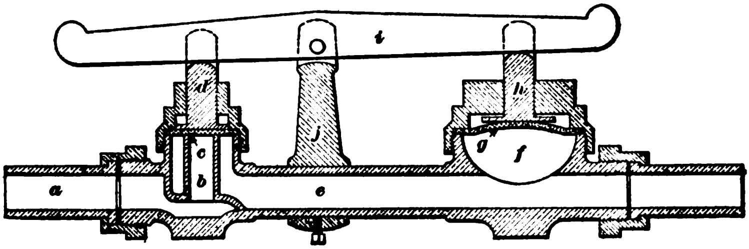


FIG. 58

Owing to the large area of *g* and the smaller area of *c*, a lower pressure per square inch is required in *e* than in *a* to cause an equal upward force upon the plungers *d* and *h*. If the fulcrum *j* is equidistant between the plungers *d* and *h*, and if the tension of the rubber diaphragms and the upward pressure upon the annular ring of the diaphragm *c* around the orifice of *b* be omitted, the areas of the orifice of *b* and of the diaphragm *g* will be inversely proportional to the pressures per square inch in *e* and *a*, respectively; that is, the area of *b* when multiplied by the pressure per square inch in *a* should equal the area of *g* when multiplied by the pressure per square inch in *e*. The pressure in *e* can be adjusted, however, by shifting the fulcrum *j* of the lever *i* along upon the tube *e*, it being provided with a suitable clamp for that purpose. Thus, if *j* be set nearer *d*, a lower pressure in *c*, and therefore under *g*, will balance the pressure under *c*, and vice versa.

Whenever the pressure falls in *e*, the water from *a* will lift *c* and pass until the pressure in *e* is restored. Should the pressure in *a* be removed by shutting off the service water or otherwise, the diaphragm *c* will be closed by *g*, its area being much greater than that of *c*, and no water can escape back through the apparatus. It thus acts as a check-valve.

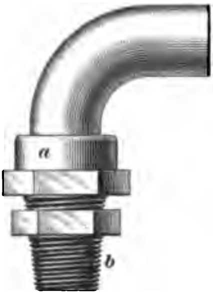


FIG. 59

SUNDRIES

107. Fig. 59 shows a **boiler coupling** and **spud** screwed together by a coupling ring *a*. The end *b* of the spud is threaded iron-pipe size for screwing into the tapping of an ordinary iron kitchen boiler. The coupling may have a washer, or may be ground. The latter is preferable.

108. Fig. 60 (*a*) shows a **chain stay** commonly used on wash-basin slabs. The basin plug is attached to a chain, which in turn is hooked to the ring of the chain stay. A nut *a* on the under side of the basin slab holds the chain stay tight. Fig. 60 (*b*) shows a **cock-hole cover** commonly used to close a cock hole in a marble wash-basin slab. It is held tight by the nut underneath.

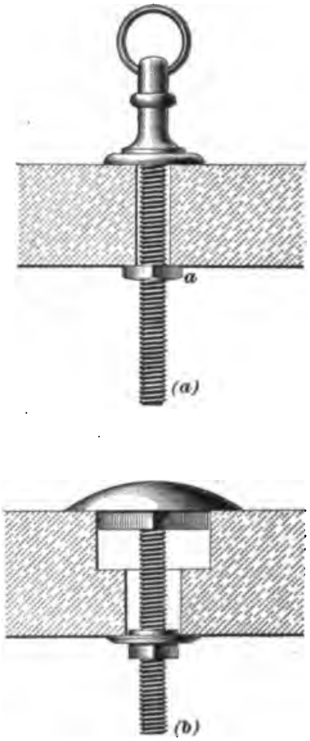
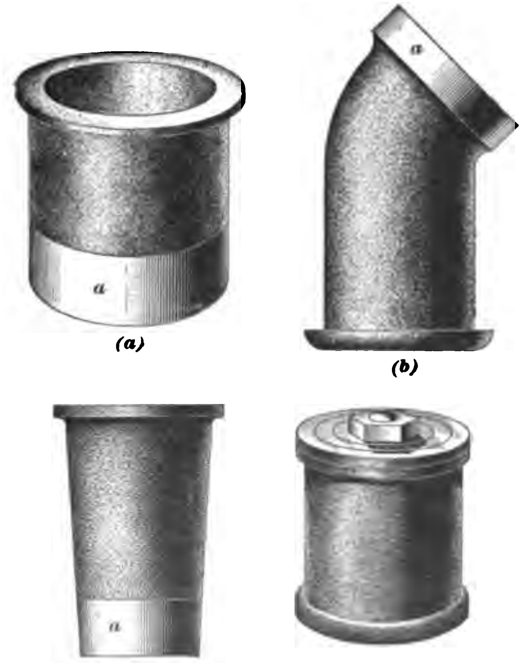


FIG. 60

109. Fig. 61 (*a*) shows a **straight brass ferrule.** The part *a* is finished smooth to a distance of about 1 inch, while the remainder is left rough.

This is used to connect a lead pipe to a cast-iron pipe, the lead pipe being soldered to the end *a*, while the other end is calked into the pipe socket. Fig. 61 (*b*) is a **bent brass ferrule** recessed on top at *a* to receive lead pipe, and beaded at the bottom for calking into a cast-iron pipe socket. The surface at *a* is finished for soldering purposes. Fig. 61 (*c*) shows a **reducing brass ferrule,** commonly used to connect 1¼- or 1½-inch lead waste pipe to a 2-inch socket. Fig. 61 (*d*) shows a **brass screw-cap ferrule** for calking into the socket of a cast-iron pipe, or trap. It is used for a handhole for cleaning-out purposes. The top can be unscrewed by applying a wrench to the hexagonal projection. The cap



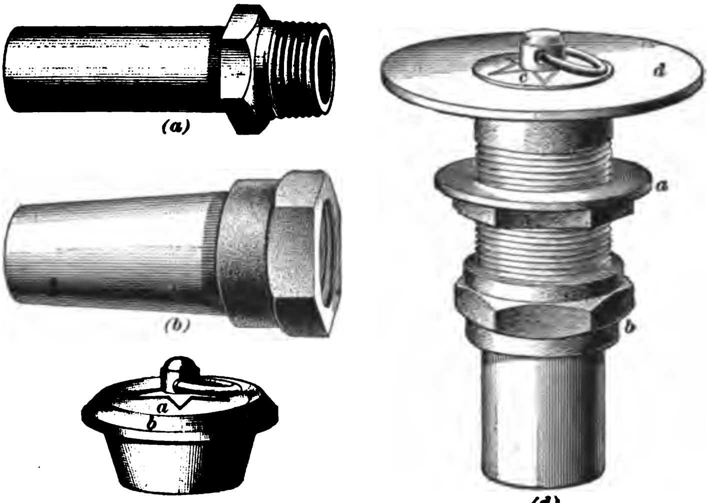
(a) (b)

(c) (d)

FIG. 61

may be made gas-tight by a washer; the best ferrules, however, have ground joints.

110. Fig. 62 (*a*) shows a **male solder nipple,** and (*b*) a **female solder nipple.** The plain ends of these nipples are finished smooth for soldering to lead pipes. The other end of the male nipple is threaded to screw into an iron-pipe fitting, and the other end of the female nipple to screw over an iron pipe. Fig. 62 (*c*) shows a common **plug** and **socket.** The plug *a* is shown set in the socket *b*. Brass plugs are ground to fit the sockets; rubber plugs, however, are commonly used. The plug and socket shown are generally used in baths lined with sheet metal. A strainer is cast on the bottom. Fig. 62 (*d*) shows a **waste plug** and **socket coupling** with locknut *a*, straight coupling *b*, and rubber plug *c*. The flange *d* sets in a countersunk part of the bath or sink to make a flush bottom. A strainer, generally cross-bars, is located inside the opening about $\frac{1}{4}$ or $\frac{1}{8}$ inch below the plug.



(*a*) (*b*) (*c*) (*d*)

FIG. 62

TOOLS

111. The **hand saw** shown in Fig. 63 is used for cutting lead pipe, wood, etc. It should have a blade about 16 inches long, with coarse teeth upon one edge and fine teeth on the other.

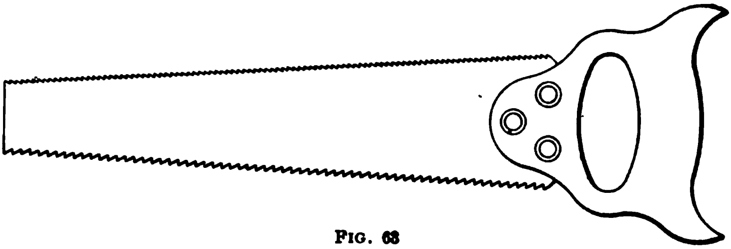


FIG. 63

112. A **hack saw** is a special saw with fine teeth. It is used for cutting brass and iron, but is not much used by plumbers.

113. **Rasps** are used for beveling sheet lead and pipe when preparing them for soldered joints. A convenient size is the 12-inch. Coarse rasps are used on heavy lead; fine rasps are used on thin or light lead.

114. **Files** are used for shaping brass and iron, and for clearing the oxide from the solder bits. A convenient size is a 12-inch bastard-cut file. To prevent the teeth of a file from filling with lead chips, first rub chalk on the file.

115. **Dividers,** or **compasses,** are used for describing arcs and circles and dividing.

116. The **tap borer** shown in Fig. 64 has a short conical bit *a*, sharp on both edges, by which holes may be made and opened out in lead pipes or sheets. The bit should be quite short,

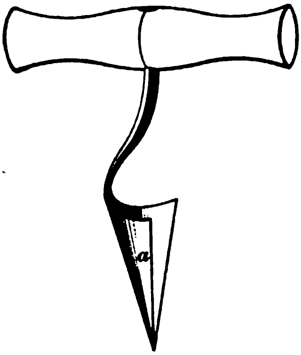


FIG. 64

so that the point will not strike the back of a pipe when making a hole in the front side of it.

117. The **bending pin** shown in Fig. 65 is made of steel, and is used for curving small pipe, and for working up the edges of holes that have been bored with the tap borer, etc.

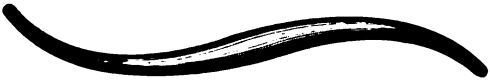


FIG. 65

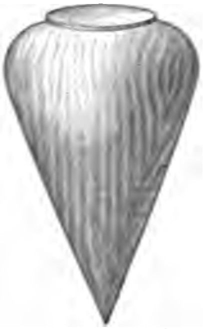


FIG. 66

118. The **turn pin,** or **tum pin,** shown in Fig. 66, is a cone made of boxwood, and is used for expanding the ends of lead pipe. A convenient size has a diameter of 2¼ inches at the large end.

119. The **shave hook,** shown in Fig. 67, consists of a steel blade *a* beveled to an edge all around and secured to a convenient handle. Shave hooks are made in many shapes; that shown in the illustration is good for general work.

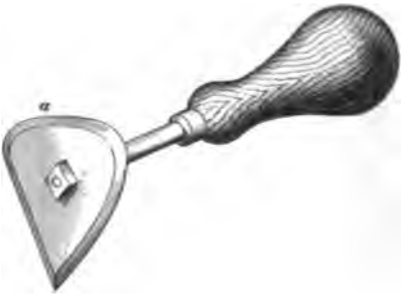


FIG. 67

120. Soldering bits are made in two forms, the **pointed bit,** shown in Fig. 68, and the **hatchet bit.** They consist of a block *a* of copper, which is secured to a convenient handle. The shape and weight of the bit are varied to suit different kinds of work. A convenient size is that which weighs about 4 pounds per pair; heavier bits are required, however, for heavy work. In the hatchet bit the copper is given the general form of a hatchet blade.

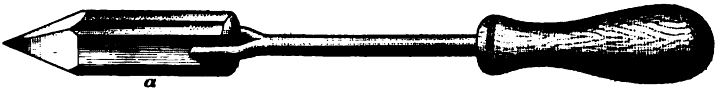


FIG. 68

121. The **dresser,** shown in Fig. 69, is made of boxwood. It is used for working sheet lead and lead pipe. Iron being harder than lead, tools made of this metal mark and bruise lead; consequently, wooden tools are used instead of iron ones for hammering or beating lead into various shapes.

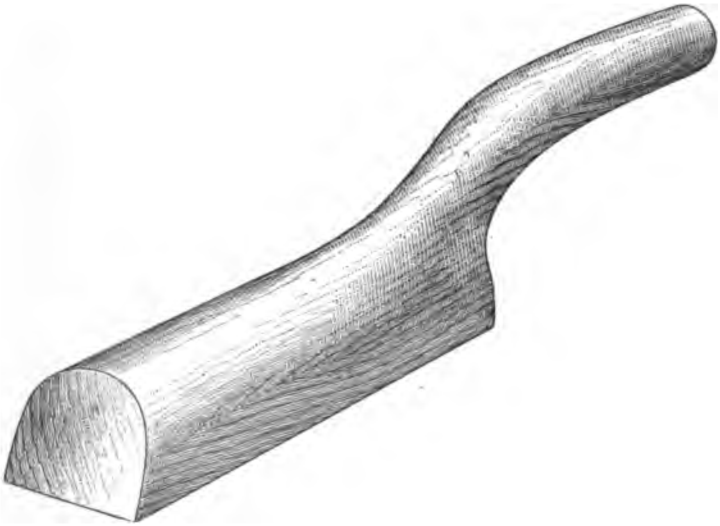


FIG. 69

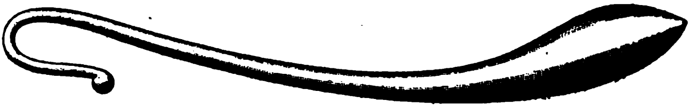


FIG. 70

122. The **tank iron** shown in Fig. 70 is of assistance in maintaining the heat required in making large wiped joints, and in wiping the seams in lead-lined tanks, etc. It is made of wrought iron. The tank iron was extensively used before gasoline torches were placed on the market. Up-to-date American plumbers do not use tank irons if a torch is available.

123. The **ladle** is shown in Fig. 71. It should have three lips, so that its contents can be poured to the right, left, or ahead, and thus work readily in all situations.

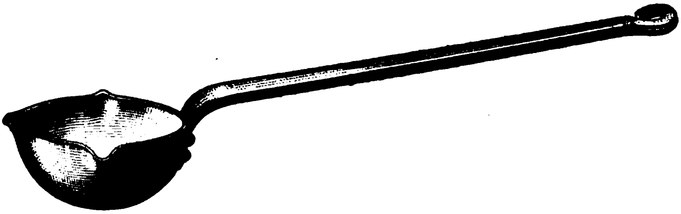


FIG. 71

124. The **solder pot** is made of iron, and for ordinary jobs it should hold 15 pounds of melted solder.

125. **Wiping cloths** are made of moleskin cloth or bed ticking, of all sizes and thicknesses. They may be made by the workmen, or may be purchased from dealers in plumbers' supplies. The sizes commonly used for underhand joints are given in the following table:

TABLE XII

SIZES OF WIPING CLOTHS

Size of Pipe. Inches	Size of Cloth. Inches	Thickness of Cloth. Layers
½ to ¾	3½ × 4	6
1	4 × 4¼	8
1¼ to 1½	4¼ × 4½	8
2	4½ × 5	8
3	5 × 6	8
4	6 × 7	8 or 10

By practice, the plumber soon decides upon the size of cloth best adapted to his own methods of solder manipulation. Many plumbers use smaller cloths than those given in the table. The sizes there given are suitable for beginners, who can reduce the size as they become more expert in handling the solder.

126. **Fire-pots** are made of various forms, to suit different fuels. Large iron *chaffers* are especially designed for burning soft coal. Fire-pots for charcoal fuel are commonly made of sheet iron, but they do not last long. A cast-iron fire-pot with a flaring top is the best for burning charcoal.

127. Gasoline fire-pots especially constructed for plumber's use are made in various ways. In general, they are composed of a gasoline storage chamber surmounted by a burner and a support for a solder pot and copper bits. Air is pumped into the gasoline chamber, which forces the gasoline up to the burner, where it flows through a heating coil and is vaporized before it is ejected from the burner. Instructions are furnished with each gasoline fire-pot. Since gasoline is a highly volatile liquid, it is advisable to light gasoline fire-pots outdoors, so that there will be no danger of the building taking fire in case of an accident to the fire-pot.

128. There are several kinds of **plumbers' torches.** The most common are the **gasoline hand torch,** which operates on the same principle as the gasoline fire-pot, and the **alcohol torch,** which is simply a flask containing alcohol and a cotton wick. This is used with a mouth blowpipe. Some of the improved forms have an adjustable mouth blowpipe attached to the torch.

129. A **yarning tool** is shown in Fig. 72. It is made of steel. The face *a* is about $\frac{1}{8}$ inch thick and about $\frac{1}{2}$ or $\frac{5}{8}$ inch wide. It is used for driving yarn or oakum into iron-pipe sockets.

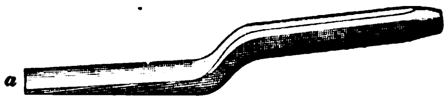


FIG. 72

130. A **calking tool** is shown in Fig. 73. It is made of steel. The face is about ¼ inch thick and about ½ or ¾ inch wide. It is used for staving or calking lead into cast-iron pipe sockets. Yarning and calking tools are made in different forms to reach around the back of pipes in confined places. Those shown are used for open, that is, readily accessible, work.

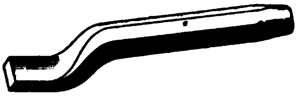


FIG. 73

131. A **cold chisel** is shown in Fig. 74 (*a*). It is used chiefly for cutting cast-iron pipes, brick, stone, etc. A **cape chisel** is shown in (*b*). It is similar to the cold chisel, only narrower at the cutting edge, being about ¼ inch wide. It is used for cutting iron, brick, or stone and for picking lead out of calked joints in cast-iron pipe, etc. A **half-round nose, or foal-foot chisel** is similar to the cape chisel, the chief difference being that the face of the chisel is ground to the form of a colt's hoof. It is used chiefly for gouging a groove in heavy iron previous to cutting it with the cold chisel. A **diamond-nose chisel** is the same as the foal-foot chisel, except that the nose is ground to the form of a diamond. It is used for the same purposes as the foal-foot chisel.

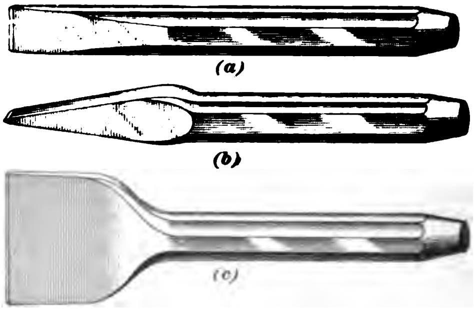


FIG. 74

132. A **floor chisel** is shown in Fig. 74 (*c*). It is simply a steel cold chisel with a very wide, thin face. It is used for driving into floor joints, cutting the tongue, and raising the boards without injuring the wood. A **wood chisel** for plumbers' use may be provided with a wooden handle, or it may be made out of bar steel. The latter is preferable. A

gouge is similar to a common wood chisel, but curved at the cutting end. It is used chiefly for cutting roads for pipes.

133. Plumbers' hammers should have straight peens, for convenience in driving in wall hooks, etc. A heavy hammer, weighing about 2½ pounds, should be used for cutting iron pipes, holes in stone walls, etc. A light hammer, weighing about 1 pound, should be used for ordinary work. The handles should be about 10 or 12 inches long, over all.

134. Fig. 75 shows an **asbestos joint runner** attached to a pipe and ready to receive molten lead. It is held in position by a special clamp, which is connected permanently to the runner by a chain. The asbestos runner *a*, which is square in section, is placed around the pipe and drawn up tight against the hub *b* and pipe *c* by the clamp *d*, which is closed in on the runner by a spiral spring. The lead is poured into the hub at the gate *e*, as shown; to prevent the lead flowing between the ends of the joint runner, a little putty is sometimes placed into the space. The lead ring then cast is thus without a projection.

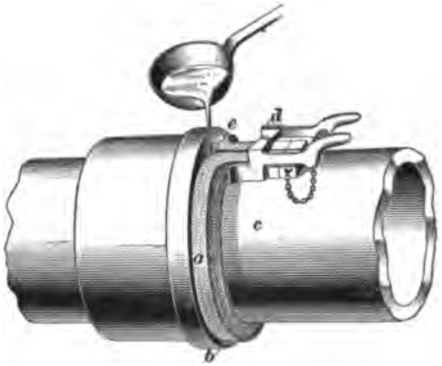


FIG. 75

135. A **spirit level** is a wooden or iron bar having a small glass tube secured near the middle. The tube is nearly filled with alcohol or some other fluid and sealed at both ends, an air bubble being allowed to remain in the tube. It is so arranged that when the bar is level the air bubble will locate itself in the middle of the glass. This is used chiefly for grading trenches, drains, etc.

136. A **rosin dish** quite popular among plumbers has three compartments, as shown in Fig. 76; the one is for rosin, another for flour paste, and the middle one for tallow. The end compartments are closed with caps *a*, *a*, and the center one is closed by a revolving cylinder *b*.

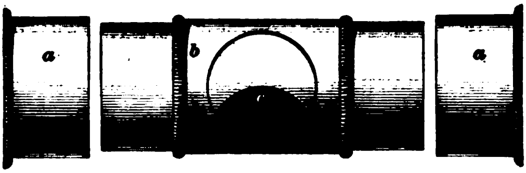


FIG. 76

137. The **screwdriver** may be of the ordinary kind. A 6-inch one and a 12-inch or 15-inch one are very useful. They must be strong and the steel must be of good quality.

138. **Brace** and **bits** are required in a plumbers' kit to bore holes in woodwork for pipes to pass through. A ratchet brace and an extension bit are most suitable—the ratchet, because it enables holes to be cut in close corners, and the extension bit, because it can be adjusted to cut the hole any convenient size.

139. A **compass saw** is necessary in cutting roads for pipes. It has a handle like a common saw, but has a very narrow blade that can make a cut in any direction. It is used for cutting holes in floors, etc., that are too large for an extension bit.

140. A **pipe bender** is shown in Fig. 77. It is simply a slightly tapering spiral-steel spring provided with a hook at one end and rounded off at the other. It is used for bending thin lead pipes having a diameter less than 2 inches.

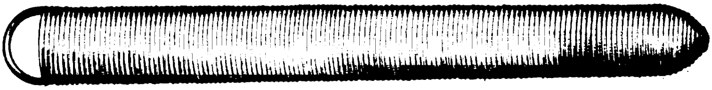


FIG. 77

141. Plumbers often have occasion to thaw out frozen pipes underground, and in other inaccessible places, by means of steam injected into the frozen pipe by a small lead tube. Fig. 78 shows a portable steam generator for this purpose, which may be set on top of an ordinary plumbers' fire-pot, the steam being generated by the heat of the fire. This device is called a **thawing steamer.** It is simply a plain cylinder *a* provided with an ordinary equipment of boiler connections for filling and safety purposes. Water is supplied to the boiler through a combination funnel and safety valve *b*. A gauge glass *c* shows the water-line in the boiler. The safety valve is used to allow steam to escape to the atmosphere if an excess of pressure is raised in the boiler. A $\frac{1}{4}$-inch lead pipe *d* is attached to the steam space of the boiler to convey steam to the frozen pipe. When steam is up, the open end of this lead pipe is pushed inside the frozen pipe until it strikes the ice, and steam is allowed to blow against the ice, thus melting it. When the pipe is entirely thawed out and the water begins to flow, the lead pipe is withdrawn and the stop-cock, through which it has been inserted, is closed; the water connections are then made up again. In thawing frozen pipes by this method, care must be taken to withdraw the steam tube when the steam ceases to flow, otherwise the lead tube may become frozen inside the water pipe and serious trouble will arise if the water pipe is not large enough to allow another steam tube to enter and thaw out the first one.

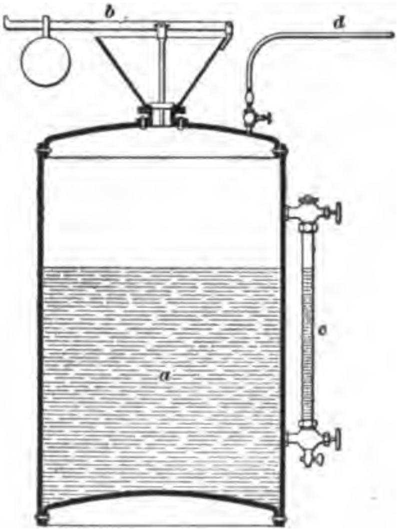


FIG. 78

142. **Pliers** are so well known as to require no illustration. They are used for quickly holding things that cannot be held by hand. An 8-inch or 10-inch size is popular.

143. A **monkeywrench** of any strong make is suitable for plumbers' use. A 10-inch wrench is a handy size.

144. A **basin wrench** is shown in Fig. 79. It is used for screwing up locknuts on the under side of a basin slab when the slab is in place. It is a convenient tool for repair work. The jaws *a*, *a* are set against the locknut. The loose part *b* is then pushed up tight and secured by a thumbscrew *c* being screwed against the shank. This prevents *a*, *a* from spreading.

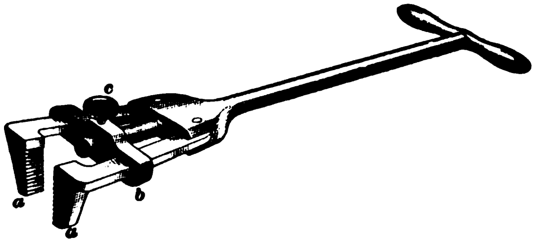


FIG. 79

145. A **pipe wrench** is shown in Fig. 80. It is used for gripping iron pipes or other round bodies, such as bolts, etc., and forms a lever by which the workman can turn the pipe or bolt into fittings, etc. The jaws *a* and *b* of these wrenches have teeth, as shown, which are caused to grip a round body placed between them, by turning the nut *c*. The wrench is turned in the direction shown by the arrow,

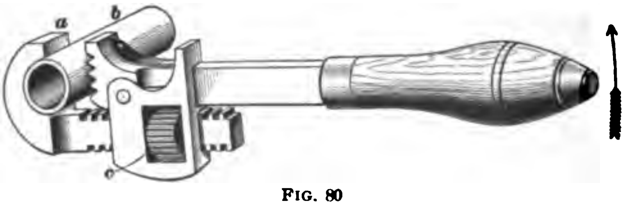


FIG. 80

and the more the force required to turn it, the tighter will the jaws grip the body placed between them. This form of wrench, called a **Stillson,** is most suitable for pipes having diameters less than 3 inches.

146. The **chain tongs** shown in Fig. 81 is generally used for pipes larger than 3 inches. This consists of two jaws, as *a*, having sharp teeth on both sides and firmly secured to one end of a long bar of iron or handle *b*, as shown. Between the jaws at *c* is fastened one end of a chain *d*. When the tongs is to be applied, the chain is passed round the pipe, as shown, and its loose end is slipped into a link socket at *e*. The handle *b* is then pulled in the direction of the arrow, which causes the pipe to turn with it.

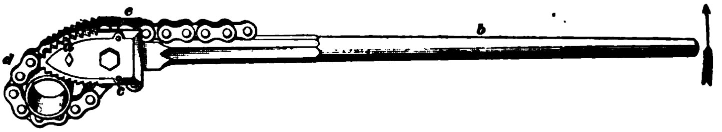


FIG. 81

147. A **friction wrench** especially adapted for screwing up nickel-plated brass pipe is shown in Fig. 82. It can be handled in a manner very similar to the common Stillson wrench. It is made from forged steel and is so formed that it cannot crush an ordinary pipe. The clamps *a*, *a* are made

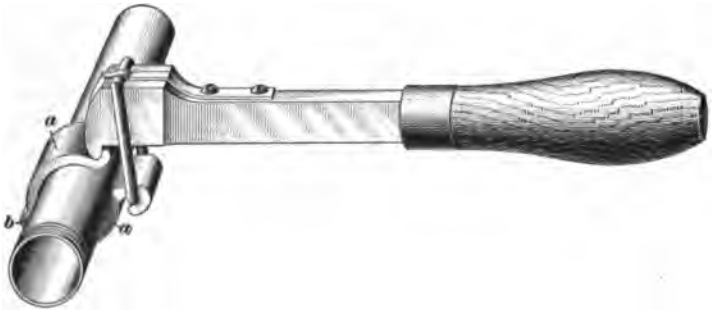


FIG. 82

in sizes that exactly grasp the standard pipe, the market sizes being ½ inch, ¾ inch, and 1 inch to fit a 10-inch handle; and 1¼ inches, 1½ inches, and 2 inches to fit an 18-inch handle. One clamp will grip only one size of pipe. This wrench has no teeth to cut into a pipe, and turns the pipe by friction only. The clamps are hinged at *b*.

148. Pipe vises are used for holding a pipe rigid while the pipe is either being cut or having a thread cut on its end. A common form of pipe vise is shown in Fig. 83, in which two hardened-steel jaws *a*, *a'* having teeth are made to grip the outer surface of a pipe placed between them by turning the handle and thus operating the screw. The vise is secured to a work bench or some other solid support by means of either lag-screws or bolts and nuts. In the figure, the vise is shown open, that is, the upper frame *b* is swung up around the center *c*, which forms a hinge. When it is to be used, *b* is swung down and is secured by the pin *d*. Pipe vises are made of malleable iron and steel, and the teeth of both the pipe vises and pipe wrenches should be kept sharp. If they become dull, they will slip and cut a furrow around the pipe, and thereby weaken it; besides, it conveys the impression of bad workmanship.

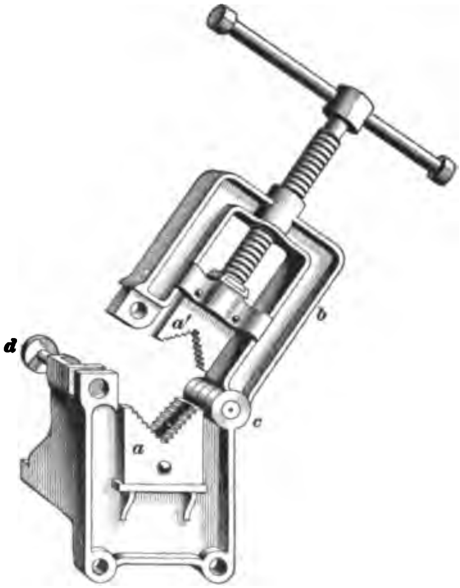


FIG. 83

149. Pipe cutters are tools used for cutting wrought-iron pipes. These cutters are made in various shapes and sizes. A very common form of pipe cutter is shown in Fig. 84, which is called a **three-wheel cutter.** In this, two knife-edge, hardened-steel wheels *a* and *b* are pivoted to a malleable-iron casting *c*, and a third *d* to an arm *e*, which in turn is hinged at about the center of the casting *c*, as shown. The other end of the casting *c* is provided with a long boss and is tapped out to receive a handle *f*, so that by turning this handle the wheel *d* and the arm *e* may be caused to move.

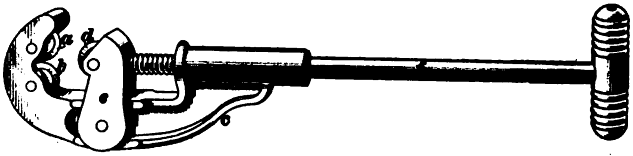


FIG. 84

150. **Stocks** and **dies,** shown in Fig. 85, are used for cutting threads over the ends of wrought-iron and brass pipes. They are made in various shapes and sizes. The dies shown in Fig. 85 (*a*) and (*b*), and also shown in the sectional view, are those parts that, on being pressed against the plain end of the pipe and revolved by means of the stocks in which they are held, will take hold and cut a V-shaped screw thread over the end. Dies are either *solid* or *adjustable.* The solid die is generally used only for small pipes, and the adjustable die for the larger ones. Two forms of **solid dies** considerably used are shown in the illustration. The die in Fig. 85 (*a*) is made of one piece of tool steel having four sets of cutting edges *a*, as shown; the die shown in Fig. 85 (*b*) is made of malleable iron except the *teeth*, or *chasers*, *a*, which are of tool steel and set in the malleable-iron frame, as shown. This die admits the renewing of the teeth, or chasers, when they are worn, and is used for somewhat larger pipes than the solid die.

151. Dies vary in thickness with the diameter of pipe to be threaded, being thinner for the smaller pipe. Solid dies cut the full depth of the thread by one operation, which wears them out rapidly, and on the larger sizes of pipes makes it very laborious to cut a thread. To overcome these objections, the **adjustable, or split, dies** have been devised. These dies are composed of two or more parts so arranged that they can be opened or closed to cut a thread on a number of different sizes of pipe, also to cut out a little of the thread at a time or to cut a thread by a number of operations instead of by one, as does the solid die.

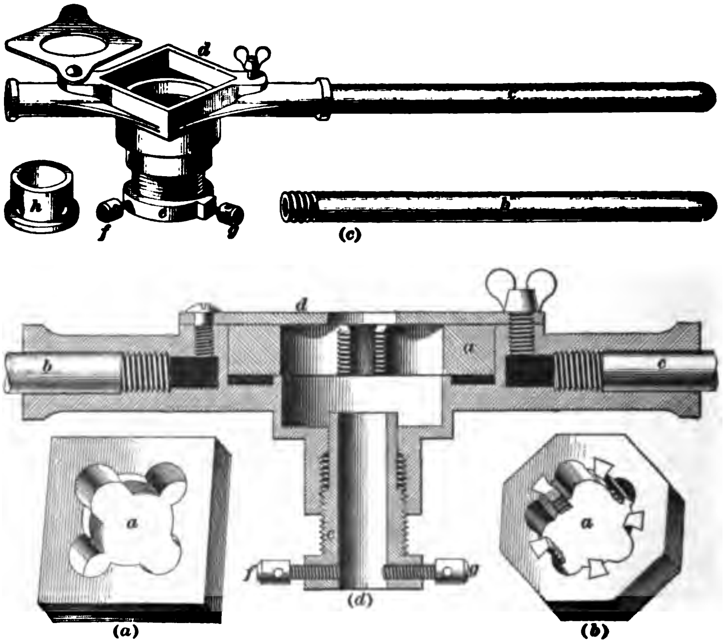


FIG. 85

152. The **die stock** shown in perspective in Fig. 85 (*c*), and in section in (*d*), is that part which holds the die solid and at right angles to the axis of the pipe on the end of which a thread is to be cut. It consists of two iron bars, or handles, *b* and *c* screwed into a malleable-iron casting *d*, in which the die *a* is placed, as shown in the sectional view. That part of the casting *d* that is slipped over the end of the pipe is supplied with a guide *e*, which moves in a threaded socket, the threads of which have the same pitch as those of the thread to be cut by the die. The guide is provided with two or more setscrews, as *f*, *g*, which when screwed down on the pipe rigidly clamp it and prevent the guide from turning; when the stock is revolved, they at the same time pull the die against the end of the pipe on which the thread is to be cut, and thus give it a start to cut the thread. It is evident that the largest diameter pipe on which a thread can be cut with a stock is one whose outside diameter is equal to the diameter of the hole in the guide. To facilitate the threading of smaller pipes than this, a bushing *h* is used, whose inside diameter is equal to that of the pipe, and whose outside diameter is equal to the inside diameter of the guide, the bushing being held in place by the setscrews *f*, *g*. The bushings and dies are changed according to the diameter of the pipe to be threaded.

153. Hand stocks like the one shown in Fig. 85 are rarely used for pipes larger than 2 inches. Larger sizes of pipe are usually cut in threading machines, which generally work with a crank. The power on the handle of the crank is multiplied by gear-wheels and the speed of the dies is correspondingly decreased. In cutting threads on wrought-iron pipes, machine oil should be freely poured on the pipes at the points where the dies are cutting. This cools the pipe and the teeth of the dies, and also lubricates the parts. It prevents the pipe from overheating and expanding, and the dies from losing their temper and becoming soft and dull.

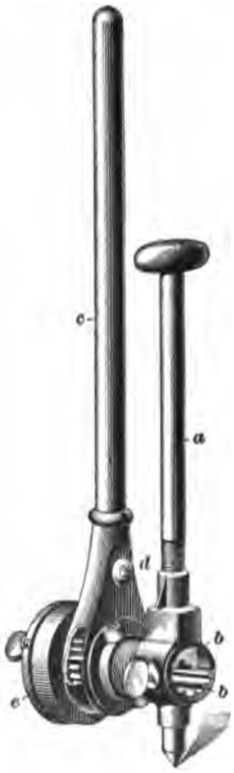


FIG. 86

154. A **ratchet stock** is a very handy tool for threading the end of a pipe where it is impossible to swing common dies, as, for example, in a trench, or in the corner of a cellar where a pipe projects too far and requires to be cut off close to the wall and threaded in place. A ratchet stock is shown in Fig. 86. The lever handle *a* with the crosshead, when screwed down tightly, is used to hold the pipe steady between the jaws *b*, *b*, while the die is turned by working the long handle *c* backwards and forwards. After the thread is cut, the die is reversed by shifting a pawl *d* near the base of the long handle, which pawl operates the ratchet *e*.

155. Plumbers are sometimes called upon to do a little lead burning, but the demand for this class of work may be so small that they may not be warranted in purchasing a special lead-burning machine. In such cases it might be advisable to do the lead burning with an air-and-gas compound blowpipe, which is convenient also for other work, such as light brazing operations, ordinary illuminating gas being used for the flame. Fig. 87 shows the **Walmsley compound blowpipe.** This tool enables plumbers to burn traps, bends, and the seams in small tanks and sinks, by using illuminating gas for the flame and Yager's salts for the flux. The blowpipe when properly regulated burns with a non-oxidizing flame; the valve *a* gives perfect control of the flame. Two rubber tubes are necessarily attached to the blowpipe; the small one *b* is for air and the larger one *c* for gas. The holes shown in the side of the gas pipe *d* are for admitting air to the gas before it reaches the mouth of the blowpipe. The air pipe *e* when adjusted is clamped in position by the thumbscrew *f*. A nipple having a small opening is screwed over the nose of the air pipe at the mouth of the gas pipe. Different sizes of nipples are provided for different kinds of work and are interchangeable on the blowpipe. There are several sizes of these blowpipes,

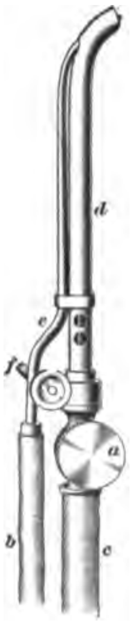


FIG. 87

but that known as the No. 1 hand blowpipe is most convenient for plumbers and lead burners. The blast is furnished by blowing into the rubber tube *b*, which is placed into the mouth.

156. Siphon jet closets, and particularly wash-down siphon closets without the jets, are liable to become choked, because of the crooked outlet passages in them. These passages are often very much contracted, and being inaccessible except from the closet bowl or from the closet outlet at the floor, are not easily cleared. To remove such obstructions, a **spiral auger,** shown applied in Fig. 88, is very convenient. It is composed essentially of a long spiral spring *a*, with an auger-like point and a handle, which, when revolved, turns the auger and works it down through the crooked passages of the closet, as shown by the illustration. The rotary movement of the auger dislodges the obstruction and the water in the bowl forces it through into the soil pipe, providing the obstruction is of such a character that it can be thus removed.

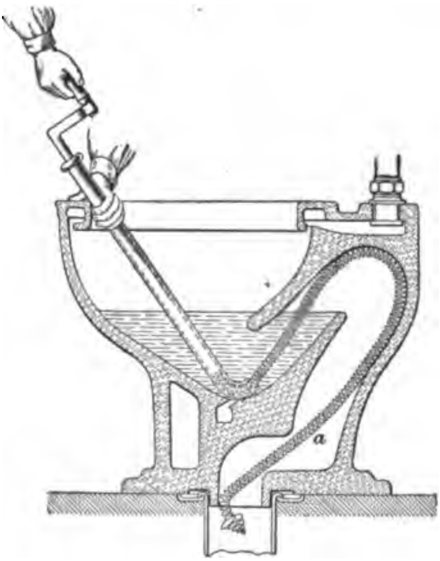


FIG. 88

157. When a new washer applied to a compression bibb, or valve, does not make it water-tight, the valve seat is usually found to be irregularly worn away. It is then necessary to face the seat down until the irregularities disappear and a new, uniform, and smooth seat is formed.

A special tool, known as a **valve reseater,** is used for this purpose. It is constructed with a bonnet *a*, Fig. 89, that may be screwed on the valve after the valve bonnet is removed. A stem *b* passes down through the center of the bonnet. A facing tool *c*, shaped as shown, is attached to the end of the stem inside the valve and a wheel or lever handle is attached to the other end. The cutter *c* is pressed down on the valve seat and revolved, which causes it to cut down the valve seat true and smooth. There are many different kinds of reseaters on the market. Every plumber's shop should contain a set of the different common sizes from ½ inch to 2 inches.

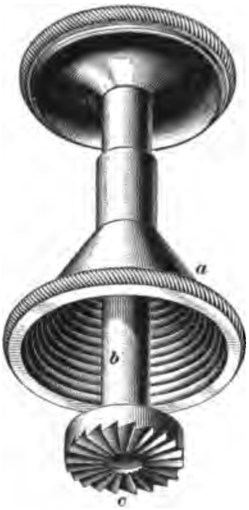


FIG. 89

158. To facilitate the work of expanding lead-pipe ends, also for expanding the edges of the metal around holes tapped in lead pipe, etc., where branches are to be wiped, a special tool, known as **expanding pliers,** may be used. Fig. 90 (*a*) shows a pair of expanding pliers. The conical end is pushed into the holes and turned alternately to the right and to the left, pressing on the handles to open the conical ends of the pliers as the hole in the lead pipe gradually becomes larger and the collar around it thus formed. In (*b*) are shown three openings in the body of a lead bottle trap, expanded with the

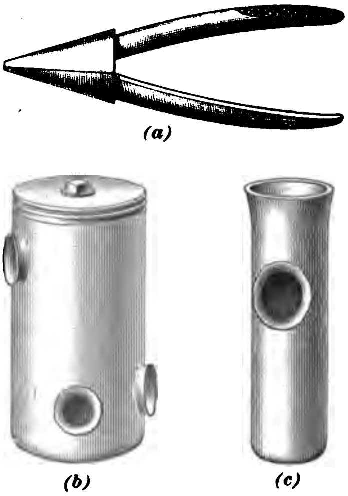


FIG. 90

pliers preparatory to wiping branch pipes into them. In (*c*) is shown a short piece of pipe; the upper end is expanded for a straight joint, and the hole shown in the sides is expanded for a branch joint. An advantage of this tool is that it does not kink or distort the pipe, like the turn pin.

SOLDERING AND WIPING

SOLDERING

INTRODUCTION

CLASSIFICATION

1. The process of joining metals by means of melting other metals having a lower fusion point than the metals to be joined, and where the parts to be joined are heated principally by either a copper bit or a blowpipe flame or by some equivalent means, is called **soldering.** The process of soldering is divided into two divisions—*soft soldering* and *hard soldering.*

In **soft soldering,** which is frequently called **soldering,** for short, the solder is composed of lead and tin and is very soft. In **hard soldering,** which is best known by the name of *brazing*, the solder is quite hard, being an alloy of copper, zinc, tin, silver, etc.

2. The process of soft soldering is divided into two classes, known respectively as *copper-bit work* and *blowpipe work.* In **copper-bit work,** a copper bit is used for melting the solder and heating the metals. The copper bit, it may be mentioned here, is in some localities miscalled the **soldering**

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iron. In **blowpipe work** the solder is melted, and the parts to be joined are heated, by means of a blowpipe flame. In the copper-bit work, and also in the blowpipe work, there is a preliminary operation known as *tinning*, in which the metals to be united are properly prepared for the final operation of soldering.

GENERAL INSTRUCTIONS

3. Melted solder exhibits a strong tendency to adhere to the surface of the ordinary metals, and to unite solidly with them while cooling. However, the least film of oxide, or of grease or dirt, upon the surface of the metal will usually prevent the adhesion; therefore, the surface must be thoroughly cleaned, or it must be coated with some substance that will reduce the oxides to the metallic state, or that will destroy the grease and will deposit a thin film of zinc upon the surface to be soldered.

The kind of solder known as **half-and-half** is suitable for joining lead, copper, brass, zinc, and iron to metals of the same kind, or for joining any of them to any other named. Block tin, however, requires a more fusible solder. Care must be taken that the temperature of the bit is not high enough to melt the tin. Rosin is the proper flux.

Copper, brass, or iron not galvanized may be prepared to receive solder by cleaning the surfaces and applying chloride of zinc. A stronger joint is insured by tinning the metal before soldering, in which case rosin is the proper flux.

Galvanized iron or sheet zinc should be cleaned with muriatic acid before the solder is applied. All metals, except lead and tin, should be tinned previous to wiping. Lead and tin only need to be shaved clean.

4. The temperature of the metals must be raised, at the point where the solder is applied, to the fusing point of the solder. In soldering metals whose temperature of fusion is but slightly greater than that of the solder applied.

such as lead or tin, care is necessary to avoid melting them and thus making a hole where it is not wanted.

Solder flows best at high temperatures, provided the temperature is not so high as to oxidize it. Solder will flow into a joint until it is chilled; therefore, it will flow farthest when it possesses a large excess of heat above that which is necessary to maintain it in the fluid condition. Soldering should not be done with bits that are barely hot enough to melt the solder, because the solder will unite only at the edges of the metal and will not flow into the joint properly.

5. The bits used for soldering must be of sufficient weight to contain the heat that is necessary to heat the metal and fuse the solder during a reasonable length of time. If they are too light, the soldering is apt to be very uneven in quality, and the bits will require such frequent reheating that they will be troublesome. If they are too heavy, then the work of handling them will be too laborious.

The metal to be soldered may be heated by mere contact with the hot bit, but the heating is done more effectively and much quicker by melting a little solder at the point of the bit. This body of solder increases the area of the contact and conducts heat from the bit to the metal with great rapidity.

In working with the blowpipe, the necessary heat is applied directly to the metal by the flame. The flame must be handled in a manner that will avoid overheating or oxidizing either the metal or the solder.

SOFT SOLDERING

TINNING

6. Purpose. — The operation of **tinning** consists in spreading a thin layer of solder (or sometimes of pure tin) upon the surfaces of other metals and causing it to adhere and make a firm metallic union therewith. The object of the tinning is to so prepare the surfaces of the metals that they will readily unite with the melted solder that is applied to them in the process of soldering joints. All the common metals become tarnished when exposed to the atmosphere, and it is necessary to remove the tarnished surface and thus expose the bare, clean metal to the influence of the solder; otherwise the solder will not, under ordinary circumstances, adhere to the metal.

7. Tinning a Copper Bit.—Copper bits must be tinned before they can be used for soldering purposes. To do this, heat the bit until it melts solder (but not red hot), then lay it on a brick or other suitable material and file one of the flat sides at the point to a distance of about 1 inch. When thoroughly clean, rub the filed surface on a piece of strap solder over which some pulverized rosin has previously been sprinkled. The hot copper will quickly melt the rosin, the fumes of which prevent the copper from tarnishing before the solder melts. The rosin also facilitates the adhesion of the solder to the cleaned copper. Now clean and tin one of the sides adjoining that already tinned, as shown in Fig. 1; the bit is then ready for use. If the bit is red hot, it will oxidize the instant that the file leaves it, and no tinning can be done with rosin for a flux. Rosin is the best flux for tinning bits for plumbers' use.

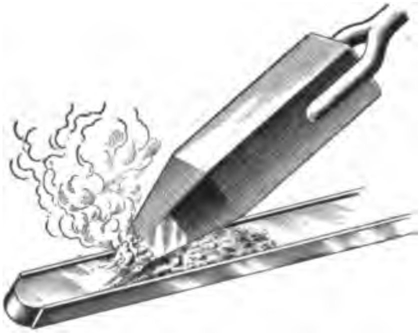


FIG. 1

A quick and convenient way of tinning a bit that is to be used for soldering other metals than lead, or tinning surfaces that must be joined with wiping solder, is to rub it, while hot, upon a block of sal ammoniac having a few drops of solder spattered over its surface. The sal ammoniac reduces the oxide, and the clean copper seizes the solder instantly on coming in contact with it.

Another quick way, which is particularly adapted for bench work, and which is quite popular with cornice makers and tinsmiths, is to dip the point of the bit, while hot, in a saturated solution of sal ammoniac and water before rubbing it on the solder. This, however, tins all four sides, which is not always desirable.

When a bit is overheated, the coating of solder, or the **tinning,** as it is called, is reduced to a yellow powder and is destroyed. The tinning must be restored before the bit can be again used.

8. Tinning Solder Nipples.—Solder nipples are made of brass; they must be tinned before they can be properly soldered to lead pipes. In order to hold the nipple during tinning, a block of wood *a* is whittled down at one end, and driven into the threaded end of the nipple, as shown in Fig. 2. The plain end is then filed perfectly clean, all the outer surface being filed off to a suitable distance, which for wiping purposes is usually from 1 inch to 1¼ inches. The cleaned surface is then rubbed with pulverized rosin, and the nipple is painted with black soil, as shown. The **cleaning** *b* is now ready to be tinned. The heated copper bit is then used to melt a little solder off the strap of solder

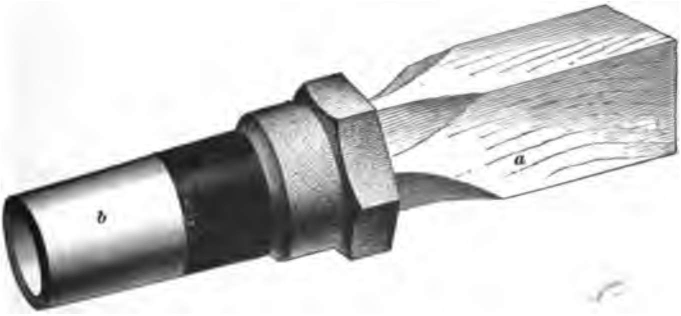


FIG. 2

on to the cleaning. The tinned part of the bit is next laid over the drop of solder, which melts and adheres to the cleaning, as shown in Fig. 3. By working the bit over the cleaned surface, the solder is made to adhere to the entire cleaning. If it does not adhere freely, a sprinkling of rosin will help it to flow. Care must be taken to leave no part of the cleaning untinned. If the tinning is done properly, the cleaning will be covered with a thin, uniform, and bright coating of solder. The nipple is now ready to be soldered to a pipe.

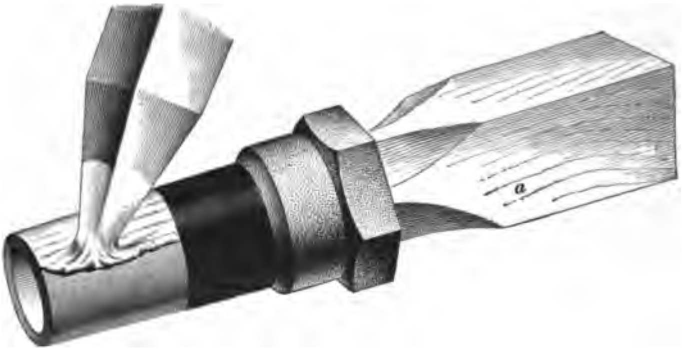


FIG. 3

9. **Tinning Spuds.**—Spuds are tinned similar to nipples, the only difference being that the tinning ends at the edge *a*, Fig. 4, instead of on the small shank *b*. This enables the

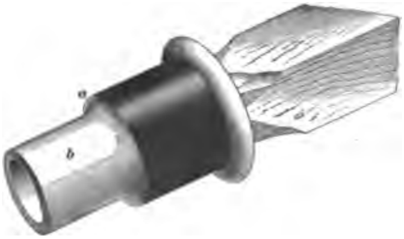


FIG. 4

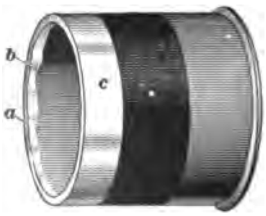


FIG. 5

plumber to wipe the joint easily and prevents the joint from being weak by a lack of solder at the place where it should be strongest.

10. Tinning Brass Ferrules.—Brass ferrules are filed and tinned the same as solder nipples, except that the edge *a*, Fig. 5, and inner surface *b*, which extends inside the ferrule about ¼ inch, are tinned as well as the outside cleaning *c*. All cast-brass ferrules are liable to have blowholes in them. It is advisable, therefore, to examine for blowholes and solder them while tinning the ferrules.

11. Tinning Ground Key Cocks.—Ground key cocks are tinned with the keys left in, since it has been found, by practical experience, that if the tinning is done with the key removed, the heat to which the body is subjected during tinning will cause the body to warp and remain warped when cooled. This destroys the ground fit between the key and body, and consequently the cock will leak in service. The parts that are not to be tinned are painted with black soil, as shown in Fig. 6.

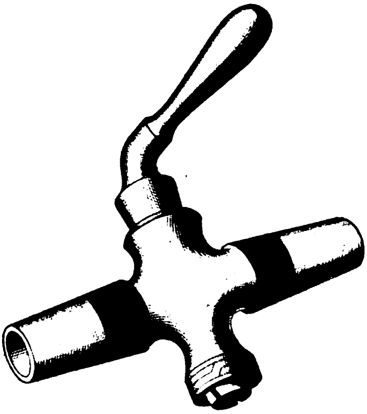


FIG. 6

12. Tinning Compression Cocks.—Compression cocks usually have rubber washers and packings. To prevent these being injured by the heat, it is advisable to remove the bonnet, valve stem, etc. during tinning, when the cock will appear as shown in Fig. 7.

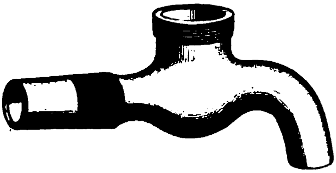


FIG. 7

13. Tinning a Bent Coupling.—Bent couplings are rather awkward to tin. The stick *a*, Fig. 8, must be cut to fit snugly, because it cannot be driven in far. The coupling ring *b* must be tied up to the stick, or otherwise secured to prevent its slipping down or working toward the cleaning while the joint is being wiped. A good plan for securing the ring is to pack thin paper in between the ring and the stick, as shown at *c*.

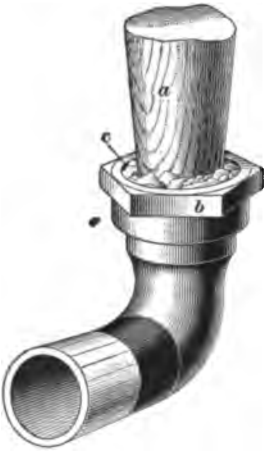


FIG. 8

14. Tinning Sheet Copper.—Sheet copper usually requires to have its edges tinned before they are bent up for lock seams. This is best accomplished by laying the sheet on an inclined plane surface and tinning the edges by working from the top down, as shown in Fig. 9. If the sheets are new and moderately clean, the edges will not require to be scraped, and can then be tinned with chloride of zinc as a flux; if they are much tarnished, they must be scraped clean before the flux is applied.

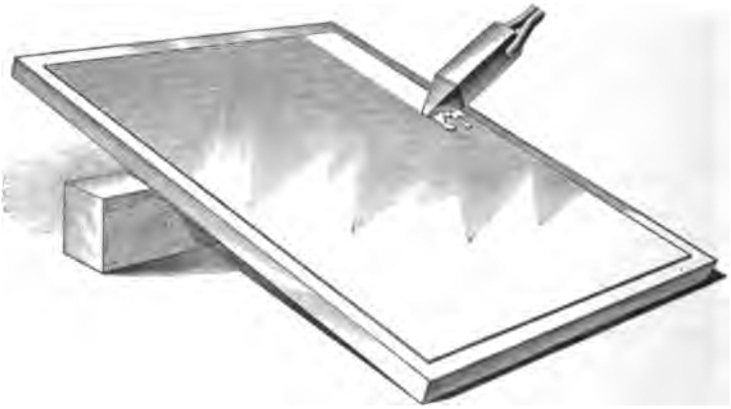


FIG. 9

15. Precautions.—In tinning metals, great care should be taken to give the tinning a uniform thickness and have it free from imperfections. Small lumps or ridges of solder in the tinning coat will interfere with the proper closing of joints and seams, and care must always be taken to remove them. Any superfluous solder can be shaken off or wiped off with clean waste or a clean cloth.

16. Dip Tinning.—Many articles can be tinned all over after they have been cleaned and coated with a flux by dipping them into melted solder. This process is known as **dip tinning.** It is bad practice to dip brass into a pot of molten solder that is to be used for wiping purposes, because some of the zinc (of which the brass is partly composed) will melt out and alloy with the solder, and will spoil it.

Articles that are composed wholly of copper may be dipped in the solder pot without injury to the solder, provided they are perfectly clean and free from filings, etc.

Iron articles may be tinned by thoroughly cleaning the surfaces and treating them with chloride of zinc or sal ammoniac before the solder is applied.

17. Soiling.—The object of soiling is to prevent the solder flowing upon those surfaces that are protected by it, or from adhering to them. It thus enables the workman to keep the solder within proper limits and to produce clean, nice-looking work, free from all unsightly splashes or irregularities.

For work that is to be done with the bit or with the blowpipe, a width of soiling from ½ to 1 inch is usually enough.

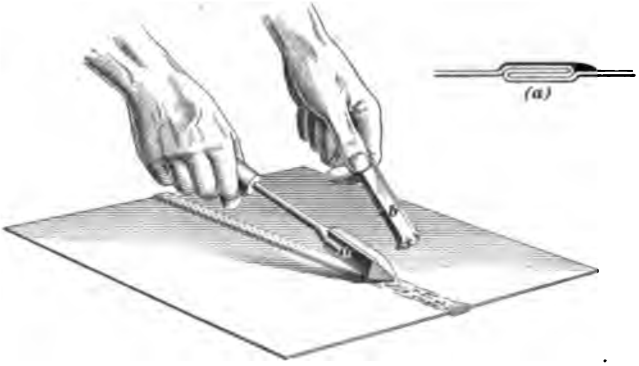
The solder should not be applied until the soiling is dry. In fair weather it will dry quickly; but if it dries too slowly, the drying may be hastened by applying a moderate heat. Strong heat will spoil it.

SOFT SOLDERING SEAMS AND JOINTS

18. Kinds of Seams and Joints.—The soldering done with the copper bit is principally on *flat* and *locked seams;* on *bead*, or *floated*, *seams;* on *cup joints;* and on *overcast joints.*

The **flat seam,** which is also called **lap seam,** is used only for joining thin sheets of tin (tinned sheet iron), copper, or zinc. In this seam one plate simply laps over the other and the two plates are soldered together in this form. It is not suitable for work requiring a strong seam. The **lock seam** is made by doubling over an edge of each sheet and hooking the sheets together. In the **bead seam,** which can only be used for comparatively thick pieces of metal, the edges to be joined are beveled and butted together, thus leaving a V-shaped space that is filled with solder applied drop by drop. The solder is afterwards given a smooth finish by melting it with the bit and drawing the latter slowly along the seam, thus causing the solder to flow. The term *flow* has been corrupted to **float** by mechanics, and this corruption has caused the seam to be known as a **floated seam.** The **cup joint** and the **overcast joint** are used in joining pipes and similar objects by soldering.

19. Soldering a Lock Seam.—A completed lock seam is shown, in section, in Fig. 10 (*a*). When starting to make the seam, all of those surfaces that come into contact in the inside of the seam must be thoroughly cleaned before the folding is done. When the metal is tinned upon one side, as in the case of tinned copper, the folds are turned so that



(b)

FIG. 10

the tinned surfaces will face each other. If the copper is without tinning, it is advisable, although not strictly necessary, to tin the surfaces that will come inside of the seam. The solder will flow easier, and there is more certainty of securing a perfect joint throughout the entire seam than without it. After the sheets have been secured in place, so that they cannot shift or get out of place while soldering, the seam should be closed with the mallet. A proper flux is then applied, and the hot soldering bit *a* is held against the head of the seam, as shown in Fig. 10 (*b*). The point rests upon the seam, and a little solder is melted from the bar *b*, and flowed to the point of the bit. As soon as the metal becomes hot enough, the solder will **sweat,** i. e., run freely, into the interior of the seam; the manner of its disappearance, or soaking, into the seam will indicate to the experienced eye whether or not the work is being properly performed.

When the temperature of the bit falls to nearly the fusing point of the solder, that is, when the bit is too cold, the solder will not flow into the interior of the seam, but will adhere at the edges only. The result is called **skin soldering**; this should always be avoided. Cold bits should not be worked back and forth over the seam. If the interior is poorly soldered, nothing but a hot bit will cause the solder to flow and spread properly.

20. Soldering Vertical Seams.—Vertical seams are very difficult for a beginner to solder properly, as owing to want of practice the solder falls down off the seam and it appears almost impossible for him to make the solder soak in. Vertical seams should be avoided as much as possible. They are likely to be skin-soldered, or **skinned,** as it is often called for short, in spite of all care bestowed upon them. If any vertical seam *must* be soldered in place, the following is one of the best methods of procedure: First solder the flat seam thoroughly; then commence at the vertical seam and work upwards. Melt off some solder on the point of a very hot and well-tinned bit. Press this against the seam, having the handle of the copper bit pointing upwards. When the seam has become so hot that the solder is about to leave the bit and run down, remove the bit instantly, thus allowing the solder to set. Repeat this operation drop by drop. The seam, if properly soldered, should resemble that shown at *a*, Fig. 11. This figure also shows the position of the bit *b* and the way in which it is fed by the solder stick *c*. An incompetent mechanic will invariably allow the solder drops to fall and accumulate at *d*, when the vertical seam will be *skinned* and very weak. To make a strong vertical seam, it is necessary to leave a body of solder on it, as shown.

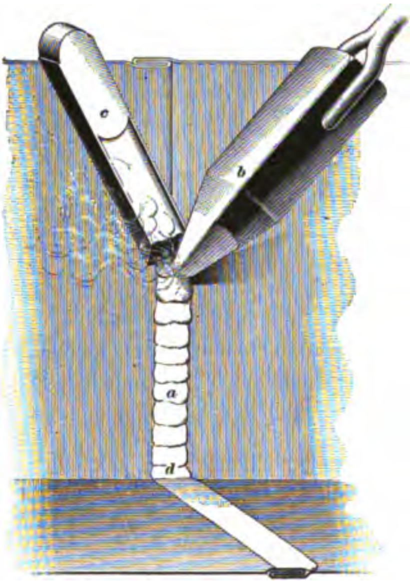


FIG. 11

21. Soldering a Flat Bead Seam.—When two comparatively thick sheets of metal, as sheet lead, are to be joined, a bead seam is generally made, as shown in Fig. 12. The edges of the sheets *a*, *a* are straightened by rasping or planing, and are afterwards beveled with the shave hook, so that when the sheets are laid as shown, a V groove exists between them. The angle of this groove should be sufficient to permit the edge of the hatchet bit to penetrate nearly to the

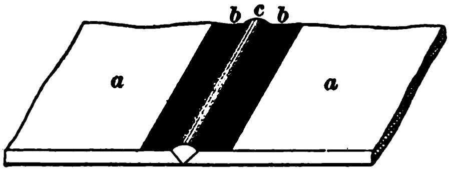


FIG. 12

bottom of it. Soil is then applied in a strip about ¾ inch wide along both edges, and on the top and bottom sides of the sheets, as shown at *b*, *b*, and this should be dried before proceeding to solder. The joint should be laid upon a board; if it rests on a metal surface, the heat will be conducted away, or **robbed,** as it is called, from the edges to be joined, so rapidly that good soldering cannot be done. If the work must be done on a metal surface, lay two or three layers of thick paper under the seam.

After the sheets are securely fastened in position, the edges of the joint may be **tacked** together with a drop of solder at intervals of 3 or 6 inches. The hatchet bit, shown enlarged in Fig. 13 (*a*), must be well tinned upon the sides, as at *a*. Solder is fed to the seam by rubbing the end of a bar *b* against the tinned side of the bit, as shown in Fig. 13 (*b*). The groove is filled with solder during the first operation, and the *floating* or smoothing and finishing, is performed afterwards as a second operation.

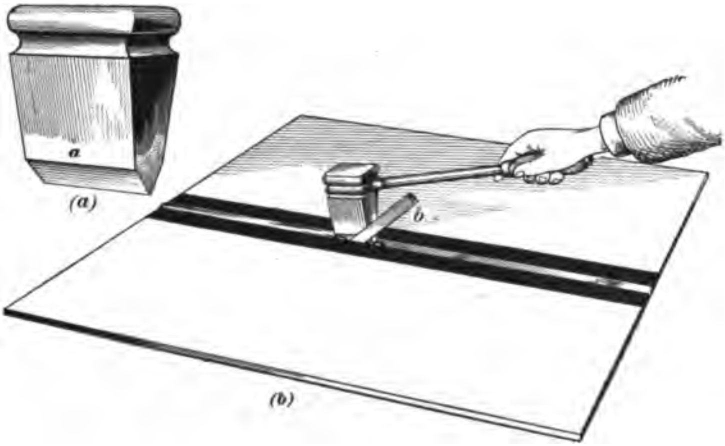


FIG. 13

22. As there is only a comparatively small margin of difference in the melting points of the solder and the lead, great care must be taken to regulate the temperature of the bit and avoid burning holes in the lead. If the bit is too hot, the work must be touched very lightly and the solder must be fed very rapidly, but as it reaches the lower limit of heat it may be allowed to bear its weight upon the seam and to proceed slowly. The seam should be filled uniformly with solder throughout its length. Then, while it is still warm, proceed to *float* it. Sprinkle it with rosin, then take the hatchet bit, sink it into the seam and draw it along slowly and steadily at a speed varying with the heat of the bit. This floating operation levels off the solder, and should leave a smooth and shining beaded seam, as shown at *c*, Fig. 12.

23. Soldering a Circular Bead Seam.—Lead pipe is often joined by means of a bead seam. The ends are beveled and are butted solidly together, care being taken that no crevice exists between the ends through which solder can run into the interior of the pipe. The parts are then tacked in position, and the groove is filled with solder, as shown in Fig. 14. The floating is done while the pipe is slowly turned. If the joint is not carefully fitted, or if it is burned, the solder is liable to flow inside, as shown at *a*, and will soon be the cause of a chokage in the pipe, should it be used as a waste pipe.

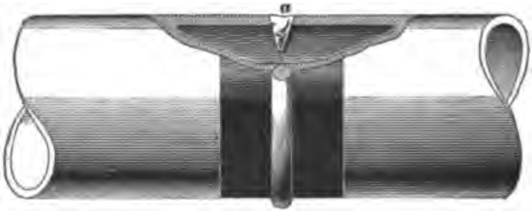
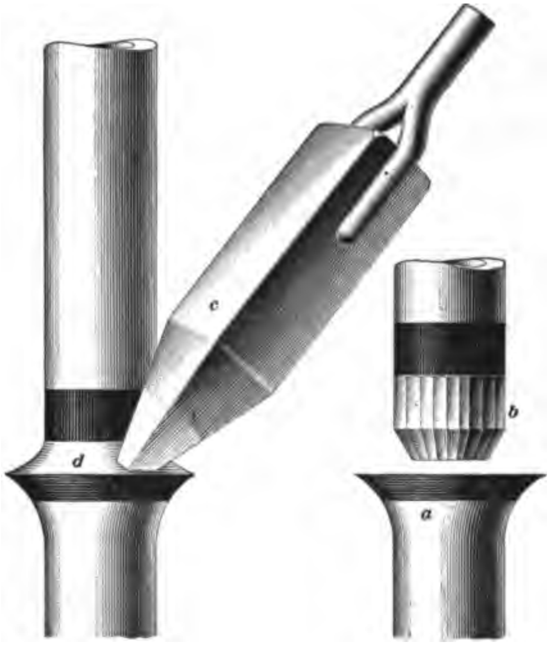


FIG. 14

24. The **cup joint,** shown in Fig. 15, is a cheap form of joint for lead pipes. It is suitable only for light pipe that is subjected to little or no pressure.

One end of the pipe is cupped with the turn pin, as shown at *a*, Fig. 15 (*a*), and the other end *b* is shaved and beveled to fit *a*. The fitting must be carefully done, so that no crevice exists between the ends by which solder may run through to the interior of the pipe. The beveled end must be cleaned to at least $\frac{1}{4}$ inch above the edge of the cup *a*, and soil should be applied to about $\frac{1}{2}$ inch above the cleaned surface. Sprinkle powdered rosin in the cup, and proceed to fill the cup with solder, being careful to avoid burning either the side of the pipe or the edge of the cup. Fill the cup a little more than full of solder, sprinkle a little more rosin upon it, and then float it by means of a long pointed bit *c*, Fig. 15 (*b*), as shown. Sink the point deep into the solder, and move it slowly around the cup. The solder should be left smooth, bright, and curved, as shown at *d*.



(b) (a)

FIG. 15

25. Fig. 16 shows a bad job. The fit between the ends was so bad that solder ran through the joint and formed beads and sharp-pointed drops, sometimes called **soldiers,** on the inside of the pipe. These catch lint, hair, etc., and thus choke the pipe. By bearing against the side of the pipe with the hot bit, a hole has been burned through at *a* and nearly through at *b*, while the edge of the cup has been burned at *c*.

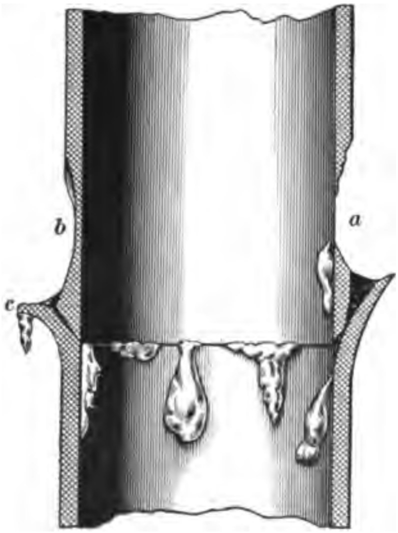


FIG. 16

26. Soldering an Overcast Joint.—The overcast joint, shown in Fig. 17, is commonly used to connect a lead pipe to a very short and small nipple or half coupling *a*, as shown. The lead pipe *b* is beveled at the end, and is closely fitted to the brass nipple. The solder is first applied near *c*, and is floated by moving the bit from *c* toward *d*, thereby overcasting the metal upon the lead pipe. The outer surface of the solder will be more or less rough, according to the skill with which the bit is handled. Care must be taken to thoroughly tin the metals to be joined before applying the solder.

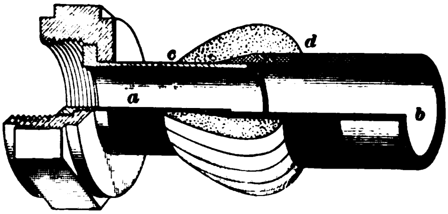


FIG. 17

27. Closing Ends.—When the end of a lead water pipe subject to low pressure (about 50 pounds per square inch or less) must be closed water-tight, it is customary to hammer the end flat and solder the edge, as shown in Fig. 18. This, however, appears rough and should not be used on exposed work. If used on high-pressure work, the flattened surfaces will bulge out; the end will thus crack and leak.

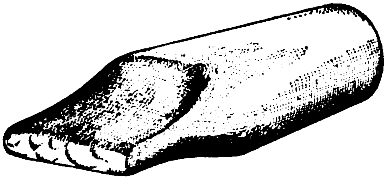


FIG. 18

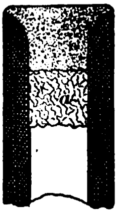


FIG. 19

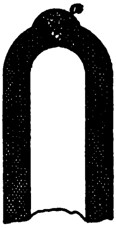


FIG. 20

A better plan is to scrape the inner surface of the pipe a distance equal to about its own diameter and to push a tissue-paper plug *a*, Fig. 19, into the pipe; next, sprinkle some rosin in the end, and then fill it up with solder and sweat it thoroughly with the copper bit until feeling assured that the solder adheres to the cleaning all the way down to the paper.

28. The best way to close the end of a water pipe is shown in Fig. 20. The end is first squared with the rasp, and then hammered in to form a hemisphere. A hole, however, exists at the center, which when soldered over, as shown at *a*, makes the end water-tight.

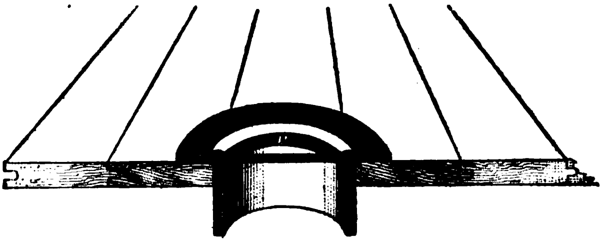


FIG. 21

29. Closet bends and other large lead waste pipes that project through the floors of a building before the fixtures are set, can have their ends closed, as shown in Fig. 21, by a flat disk *a* soldered over the opening. This keeps dirt out of the pipes and prepares the ends for the usual water test. But as a flat end on a 4-inch pipe will not resist a heavy pressure, it is advisable to taper the end of the bend with the dresser, as at *a*, Fig. 22, and then solder the point before securing the pipe in place, when it is known that a heavy pressure test is to be applied. This end is stronger than the pipe itself.

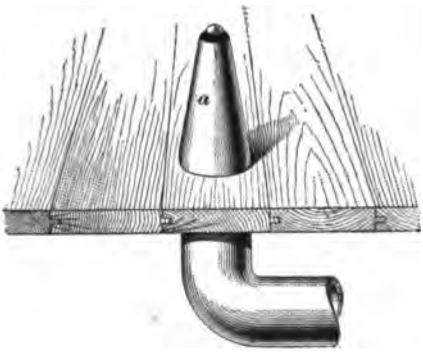


FIG. 22

30. Soldering Lead Tacks to Pipes.—Lead tacks are soldered with the copper bit to the back of lead pipes, as shown in Fig. 23. The pipe is shaved (scraped with the shave hook) at the parts *a*, *a*, and the grooves formed when the

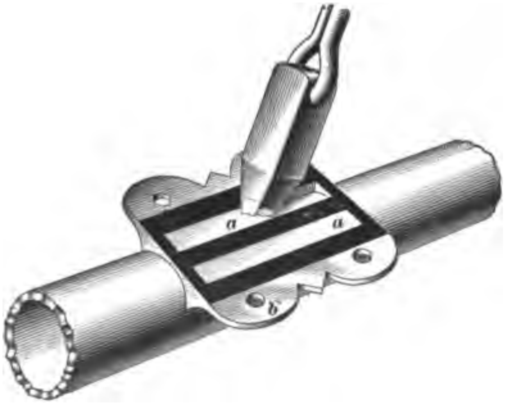


FIG. 23

tack *b* is placed in position are filled with solder and thoroughly sweated. In soldering on pipe tacks, it is necessary to hold the bit on the pipe rather than on the tack, in order to heat the pipe properly. If this is not done, the solder will not adhere strongly to the cleaning of the pipe and the tacks will break away at this place. Tacks must be thoroughly sweated to the pipe, or they are useless.

31. Repairing Frost Bursts.—In very cold weather, the water contained in lead pipes will often freeze and burst the pipes. The best method of making the pipe serviceable again is to cut out the burst portion and fit in a new piece of pipe. But in the rush of work that often accompanies severely cold weather, it is frequently necessary to make temporary repairs. A section through a **frost burst** is shown in Fig. 24 (*a*). To repair it, the metal around the burst is hammered in to close the opening. The pipe is soiled as far as necessary and shaved to a distance of at least $\frac{3}{8}$ inch all around the split; it is then sprinkled with rosin. The cleaning is now thoroughly tinned and finally soldered over, leaving on a heavy body of solder, as at *a*, Fig. 24 (*b*), to strengthen the pipe against the pressure. A section through the soldered portion is shown in Fig. 24 (*c*).

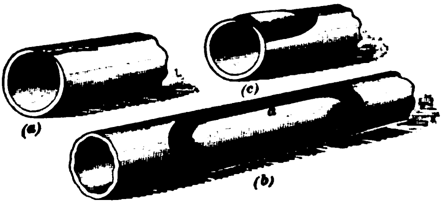


FIG. 24

32. Blowpipe Soldering.—Blowpipe soldering is done chiefly on small tubing and other small articles. The tube is prepared in the same manner as a cup joint. The solder is applied by holding a thin strip of it in the flame close to the joint, so that the molten part will fall into the cup. When the cup is full of solder, it is sweated by heating the joint all around, and causing the solder to flow, which makes a clean and strong joint.

In Fig. 25 is shown the manner of making a blowpipe joint, in which *a* is the blowpipe blown by the mouth, *b* an alcohol lamp, and *c* the pipe in which the joint is to be made.

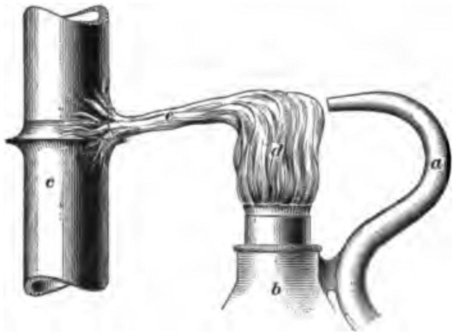


FIG. 25

By means of the blowpipe, the alcohol flame *d* is blown against the sides of the pipe as shown. To obtain the best results, the blowpipe should be held in such a position that the portion *e* of the flame *d* when blown against the pipe will be noiseless. The wind pressure should be steady and its point of application to the flame should be constant. This manner of soldering is best adapted for thin tubes of block tin or tin alloys whose temperature of fusion is low, as the heat can be applied to the pipe or to the solder at will. The pipe can be uniformly heated to the fusion point of the solder with little danger of burning it. Care must be taken to keep the flame shifting about so as to avoid too much heat at one spot, as otherwise ugly holes are apt to result.

TABLE I

MELTING POINTS OF METALS

Metal	Temperature. Degrees F.	Metal	Temperature. Degrees F.
Cast iron	2,192	Zinc	680
Copper	2,100	Lead	626
Silver	1,800	Bismuth	505
Brass, common	1,900	Tin	446
Antimony	1,000	Sulphur	228

33. Melting Points of Metals.—The average temperatures at which different metals melt, which temperatures are said to be the **melting points** and also the **fusing points,** are given in Table I. The fusing point varies with the purity of the metal, and the fusing points of alloys vary according to their composition.

BRAZING

TOOLS AND SUPPLIES

34. Brazing is a process of joining two or more metals by a solder known as **hard solder,** whose temperature of fusion is much higher than that of soft solders, and whose tenacity is greater. Hard solders are composed of alloys of copper, zinc, tin, silver, etc. Only those metals whose temperature of fusion exceeds that of hard solders, such as iron, copper, and brass, can be brazed. In this class of soldering the temperature required to fuse the solder is so high that soldering bits cannot be used.

35. The heat is usually applied to the parts to be brazed by means of an intensely hot blowpipe flame.

Small articles may be brazed with a mouth blowpipe, but the sizes of pipe usually handled by plumbers require a compound blowpipe, which uses common illuminating gas for fuel and is blown by a blast of air from a bellows. Larger jobs, having a considerable weight of metal to be heated, are executed in a forge fire. For brazing collars, etc. upon 2- or 3-inch tubing, the fire is arched over with coke, thus making a hot chamber in which the work may be uniformly heated.

36. In Fig. 26 is shown a very convenient form of **blowpipe** to be used in connection with a bellows. This is composed of a gas pipe *a* having a lever-handle controlling cock attached; an air or blast pipe *b*, also having a lever-handle controlling cock attached; and an iron-pipe nozzle *c* joined by a special casting to the pipes *a* and *b*.

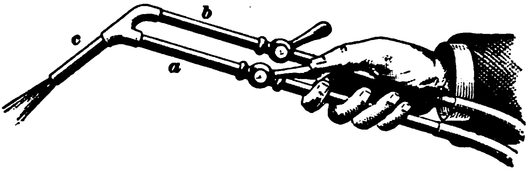


FIG. 26

37. In Fig. 27 is shown a form of **blower** suitable for supplying air to the blowpipe. It is composed of a single-acting bellows having an air inlet check-valve in the bellows, situated on the inside of the bottom board *a*, and another on the upper side of the pressure board *b* and within the rubber storage bag *c*, which is enclosed by a network to prevent its being inflated too much.

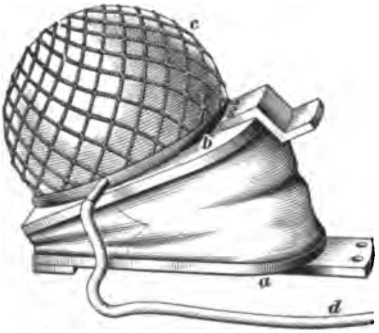


FIG. 27

The bellows are operated as follows: The top board, which is hinged at the lower end and supported by a spring within the bellows, on being pushed down with the foot compresses the air within the bellows and forces a portion of it through the upper check-valve into the rubber bag. When the weight of the foot is relieved from the pressure board, the bellows will be again filled with air by the spring raising the pressure board. The pressure of the foot of the workman, being repeatedly applied to the pressure board, will in this manner fill the rubber bag with compressed air, which flows to the blowpipe through the rubber tube *d* when the air cock at the blowpipe is open. The elasticity of the rubber bag serves to equalize the pressure of the blast.

This form of blower is capable of furnishing a strong and nearly continuous blast through a jet ¼ inch in diameter.

38. The blowpipe should be connected by rubber tubing to a gas burner or other supply and to the blower, care being taken that the bore of the tubing is large enough to avoid excessive friction.

Air is mixed with the gas before it is consumed for several reasons, but chiefly because an all-gas flame is low in temperature and gives off products of combustion that not only tarnish the metal, but also cover it with a coating that separates the flame from the metal being heated.

The gas should be turned on first and should be lit at the jet; air is then admitted gradually until the flame is brought to the proper size and color. If too much gas is admitted, the flame will be yellow and will blacken the work by depositing a film of carbon upon it. If too much air is admitted, the flame will be short, ragged, and noisy and the temperature will be too low to properly heat the metal. The flame is at its greatest heat and best condition when it burns with a pale-blue or bluish-green color, without any white or yellow parts.

THE OPERATION OF BRAZING

39. The article to be brazed must be well supported, and the seam should be well bound together with iron wire to prevent the edges warping out of place when heated. **Spelter** or hard solder is placed over the seam in such a manner that when it fuses it will flow, by gravity, into the seam. Powdered borax is then sprinkled over the seam for a flux, and the blowpipe flame is applied chiefly upon the thick parts of the metal at first, the idea being to heat the mass uniformly to the temperature of fusion of the spelter.

The heat of the metal is then increased, care being taken to avoid giving much more heat to the spelter, otherwise it may be burned or spoiled. As soon as the metal is hot enough, the borax will fuse and flow over the parts; and as the heat rises a little higher, the spelter will melt and flow into the crevice and adhere to the faces of the joint. The spelter will sweat into a crevice for a considerable distance, if the metal is clean and is hot enough.

40. The melting point of the spelter and of the metal to which it is applied may not differ more than 300° or 400°; consequently, great care must be exercised to avoid overheating the metal. The heat must be applied uniformly, otherwise the work is liable to warp; and if the flame is directed upon one spot too long, a hole is likely to be burned at that point. When brazing metals that have a low melting point, the blowpipe flame should be promptly withdrawn as soon as the spelter flows.

Sometimes the composition of brass tubing and sheet brass is so uneven, or they are so contaminated by chemical impurities, that brazing cannot be satisfactorily performed upon them. Such material may be used, however, for jobs that require only soft soldering.

Brass tubing is very brittle when hot; consequently, it should not be moved until it has cooled. The process of brazing softens the parts that are heated, and these do not return to their original hardness on cooling.

41. Small articles may be heated in a charcoal fire without the blowpipe. A blast may be used to urge the fire, if needed. Large or heavy jobs may be heated in a forge fire, for which clean coke free from sulphur is commonly used. To braze successfully, three things are required: first, a proper degree of heat, neither too low nor too high; second, uniform heating; third, proper fluxing.

In selecting the spelter to be used, that which will melt at a temperature lower than the melting point of the metal to be brazed must be chosen.

When brazing pieces to brass tubes that are made with a brazed seam, it is unsafe to use spelter, because of the liability of opening the seam. A more fusible solder, such as silver solder, should be used.

KINDS OF JOINTS

42. In Fig. 28 is shown a number of joints, suitable for different jobs. The joint shown in Fig. 28 (*a*) is called a **butt joint**; the lumps of spelter at *a* are placed in position ready for fusion. The strength of this joint is small, being in proportion to the actual area of the edges that are united by the spelter. The strength is greatly increased by **lapping** the plates, as in Fig. 28 (*b*). An equal amount of strength may be secured and the appearance greatly improved by **beveling,** or **splaying,** the edges, as in Fig. 28 (*c*), provided the plates are thick enough to permit the beveling to be extended to a sufficient width.

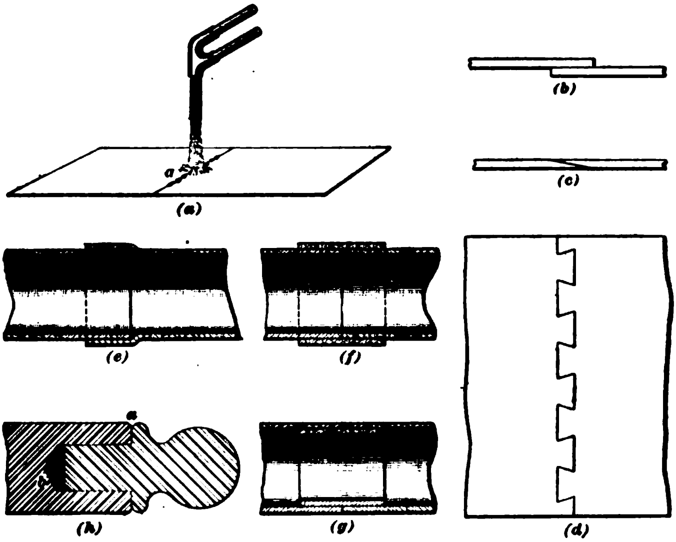


FIG. 28

The strongest joint for sheet metals is made by **dovetailing** the edges together before brazing, as in Fig. 28 (*d*).

Thin tubing may be joined by a **slip joint,** as shown in Fig. 28 (*e*), by first annealing one of the ends and forming it into a socket. The end is flared out by means of a drift plug, care being taken not to split the pipe, after which the metal is expanded by hammering until the other end will enter properly.

Circular butt joints may be strengthened by means of a band put on externally, as in Fig. 28 (*f*), or by an internal ferrule, as in Fig. 28 (*g*).

A knob brazed to the end of a rod is shown in Fig. 28 (*h*). To do this job properly, the spelter must be made to flow into the socket and secure the shank of the knob. A good job cannot be made by merely securing the edges at *a*. The rod should be held vertically in a charcoal fire until the socket is well heated, at the same time heating the knob also. Borax and spelter are then placed in the socket, and as soon as the spelter is melted the shank of the knob should be inserted and pressed into place. The spelter will flow outwards by being displaced by the shank and will make sure of filling the entire joint; or the space *b* at the end of the shank may be filled with spelter, as shown, and the knob inserted. If the knob and socket are then heated in an inverted position the spelter in *b* will flow, by gravity, around the shank and sweat down to the rim *a*.

WIPING

INTRODUCTION

CLASSIFICATION

43. The general principle involved in the process of joint wiping is that of heating the parts to be joined by the metal employed to join them, and of wiping that metal (solder) into desirable shapes at the proper places by means of a cloth while the metal is in a plastic condition.

The numerous kinds of wiped joints may be classified as *underhand joints*, *upright joints*, and *seams*. The first and second classes may be subdivided into *straight* joints, *branch* joints, and *flange* joints. The third class may be subdivided into *countersunk*, *raised*, and *corner* seams.

GENERAL INSTRUCTIONS

44. The process of making joints, which is called **wiping,** is used for joining lead to lead or to brass or copper. In making these joints, the metals to be joined should be heated to a temperature equal to that of the fusing point of the solder applied. Care should be taken that they are not heated to their own melting point. The parts are heated by pouring over them a quantity of molten solder, the proper temperature of which varies with different classes of work. The solder usually employed for wiping is composed of 2 parts of lead to 1 part of tin and melts at a temperature of about 441°. When used for wiping lead, it should be heated nearly to, but not much over, 626°, which is the fusion point of lead. This allows a margin of about 185° that is available for heating the metals to be joined. The solder pot should be kept as nearly as possible at that temperature, judging the temperature by the appearance of the molten metal. At this temperature no yellow crust will form on the surface, and the metal will not show even the faintest reddish color in a perfectly dark room.

45. In wiping joints on lead pipe, the parts to be joined are scribed, soiled, shaved, beveled, and cupped, as shown in Fig. 29. The parts must be carefully fitted together, so that solder cannot run through to the inside of the pipe. To prevent the shaved portions *a*, *b* from tarnishing before wiping, they should be rubbed with mutton tallow, which also forms the flux. The part *c* should also be shaved and greased.

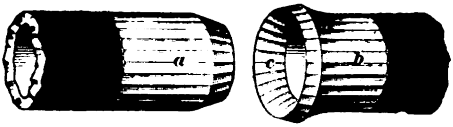


FIG. 29

46. Fig. 30 shows a wiped joint in section after the pipes *a* and *b* have been pressed tightly together and a joint wiped over their cleanings.

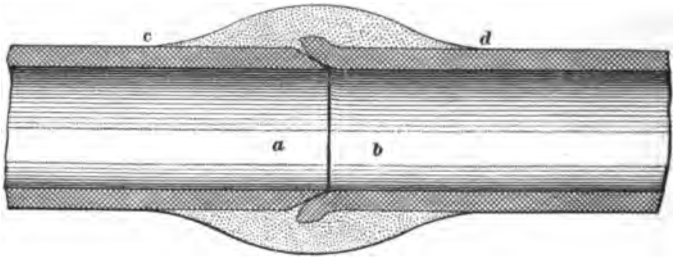


FIG. 30

The length of the joint, that is, the distance between *c* and *d*, should be about equal to that given in the following table:

TABLE II

LENGTH OF UNDERHAND WIPED JOINTS

Diameter of Pipe. Inches	Length of Joint. Inches	Diameter of Pipe. Inches	Length of Joint. Inches	Diameter of Pipe. Inches	Length of Joint. Inches
$\frac{1}{2}$	$2\frac{1}{8}$	$1\frac{1}{4}$ water	3	2 waste	$2\frac{1}{4}$
$\frac{5}{8}$	$2\frac{1}{4}$	$1\frac{1}{4}$ waste	2	$2\frac{1}{2}$ waste	$2\frac{1}{2}$
$\frac{3}{4}$	$2\frac{1}{2}$	$1\frac{1}{2}$ water	$3\frac{1}{4}$	3 waste	$2\frac{1}{2}$
1	$2\frac{3}{4}$	$1\frac{1}{2}$ waste	$2\frac{1}{4}$	4 waste	3

For pipes larger than 4 inches the joint may be from 3 to 4 inches long, if it is made in a horizontal position. Joints that are made shorter than given in the above table are liable to be weak, and those made longer involve a waste of solder. Upright joints on waste pipes usually need not be more than 2 inches long.

47. The parts should be carefully secured in place, so that they cannot shift while the joint is being wiped. A space of at least 4 inches must be had below and on both sides of the joint, to provide room for the movement of the hands and the cloth.

48. To make a joint in an ordinary $\frac{3}{4}$-inch lead water pipe, about 10 pounds of solder should be melted in the pot and heated to the proper temperature. Warm the wiping cloth until it becomes pliable, and hold it in the left hand, steadying it with the thumb, as shown in Fig. 31. The cloth should form a dish, or hollow, to receive and retain the solder that falls from the joint, in order to heat the under side of it. The parts that are to receive solder having been rubbed with mutton tallow and securely fastened, the solder in the pot is thoroughly stirred and taken up with a ladle. The solder is then slowly poured over the joint, taking care to heat the parts uniformly all around. When a quantity of the solder has been caught in the cloth, it should be worked around on to the top; more solder is then poured on this, catching the surplus with the cloth, as before, and heating

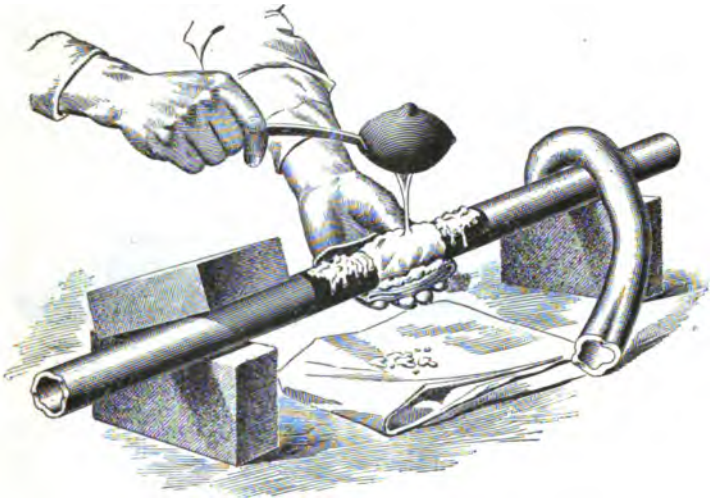


FIG. 31

the under side with it. When the solder on the pipe has become so hot as to be plastic, and is inclined to slide or drop off, and if it is certain that the surfaces are thoroughly tinned and that the pipe is sufficiently hot to maintain the solder in a plastic condition long enough to perform the necessary work, and also that there is enough plastic solder to make a good joint, pouring should be stopped and the wiping begun. The colder pieces of solder that have set, or are beginning to set, are first thrown off the joint; then the edge of the cleaned parts that limit the ends of the joint are found, and the solder is formed into the shape desired, hollowing the cloth for that purpose. At the time of forming the joint, all the superfluous solder should be thrown off. The joint is then finished by working the cloth around from bottom to top on both sides, and by finally drawing the cloth lightly across the top. This movement frequently leaves some solder projecting over the soiling, as shown at *a* in Fig. 32. This should be broken off as soon as formed, by lifting it with a knife blade. It should not be cut off with a knife, since the lead pipe is still quite soft and the blade is very apt to cut into and weaken it.

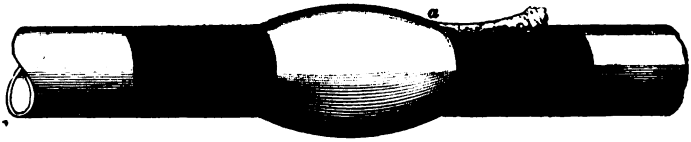


FIG. 32

Some workmen finish wiping with a very quick motion of the cloth, which throws the surplus solder tangentially from the joint and leaves the line of finishing hardly visible. This method scatters the solder over the floor, where it picks up impurities.

When the wiping is completed, the joint should be cooled quickly by blowing a spray of water on it to save time, because the joint must not be handled until it has cooled. Rapid cooling also chills the surface and prevents the tin from separating from the lead in cooling and settling to the bottom of the joint. It also improves the appearance of the joint by making it bright.

The liability to overheat the pipe and burn holes in it increases with its thinness and diameter.

EXAMPLES OF JOINT WIPING

WIPING AN UNDERHAND JOINT

49. The following ten illustrations are taken from photographs of a plumber at work making a plain **underhand wiped joint** on 1-inch AA pipe.

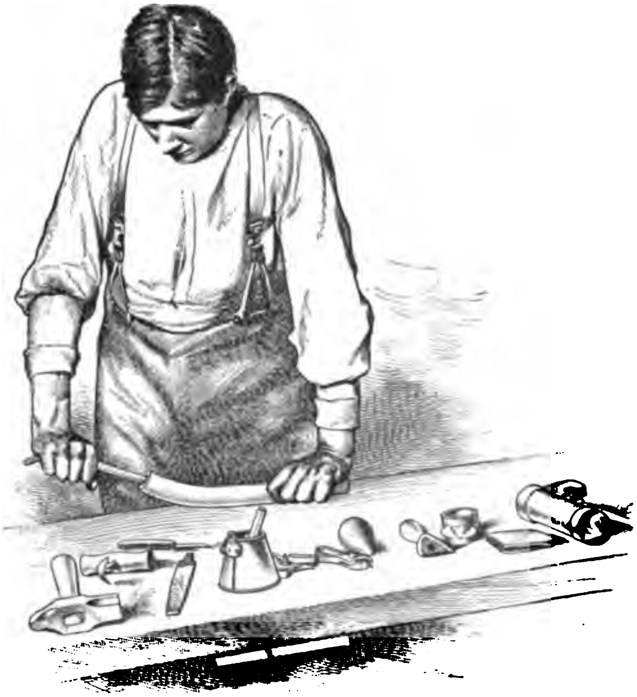


FIG. 33

Fig. 33 shows the common way of straightening the end of a lead pipe, but it does not show the evil effects. A steel bending pin is inserted into the end of the pipe, the point bearing on the middle of the inside of the curve. Force is brought to bear on the pin and the pipe, as shown, and the pipe is thus straightened. This method, however, sinks the point of the bending pin deep into the lead and damages the pipe very much, although the damage is not visible on the outside.

50. It is a difficult matter to saw a lead pipe perfectly square across; therefore, the end of the pipe must be squared after being cut. It is necessary to have the end square so that in preparing the joint the parts will form a neat fit. Fig. 34 shows the plumber squaring the end of the pipe with a rasp. As the rasp cuts deep, he must hold the pipe very steady.

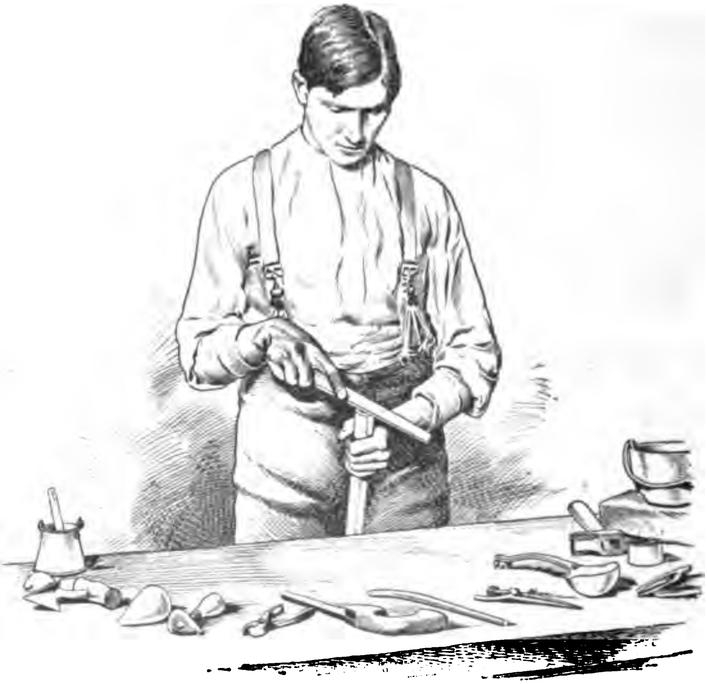


FIG. 34

51. Having squared the ends of the pipe, the plumber takes the turn pin and drives it into the end of one of the pieces with a hammer, as shown in Fig. 35, thus swaging the end into the form of a funnel mouth. Here it will be noticed that the pipe does not rest on the bench while the plumber is hammering on the turn pin. If it did, the force of the blow would bend the pipe and the swaging would not be made central. To prevent the thickness of the pipe around the swage from occupying too much space, it is rasped off to a thin edge. The swaged end is called the **female end,** and the end of the other piece of pipe, which fits into the swaged end, is called the **male end.** The bevel on the male end should be very neat and true, and the

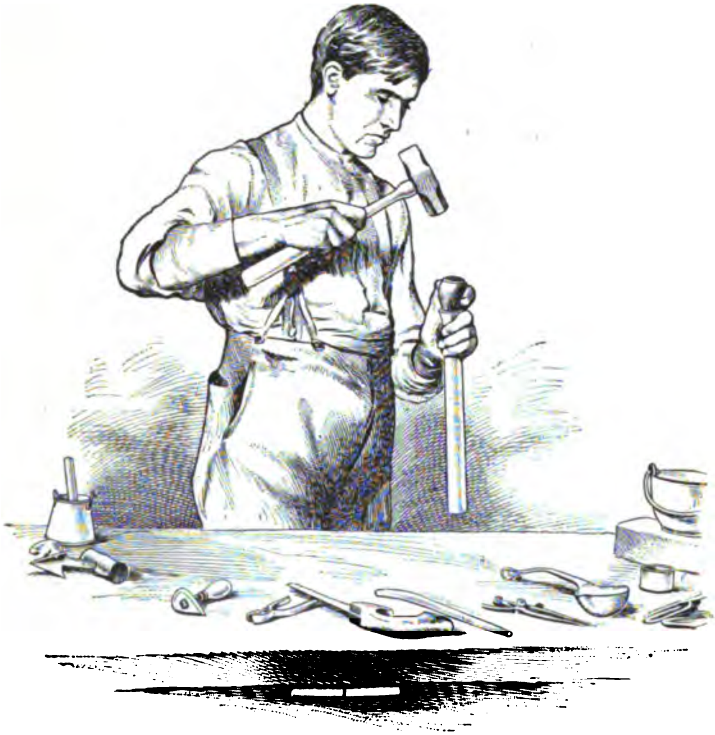


FIG. 35

rough tooth marks of the coarse rasp should be smoothed down with a fine rasp. The male end should slip into the female end $\frac{1}{4}$ inch, at least; it must fit closely all around, and be solder-tight; otherwise, molten solder will flow into the pipe when the joint is being wiped and make what plumbers call a **solid joint.**

52. The next part of the work is soiling the ends that are to be joined together, as is shown in Fig. 36, the object being not to make the joints "look pretty," as some laymen suggest, but to prevent solder from sticking to the pipe where it is not wanted. To make the soil take hold of the pipe, the ends are first rubbed with chalk to a distance of 4 or 5 inches. Then the ends are painted with the soil, as shown, and allowed to dry.

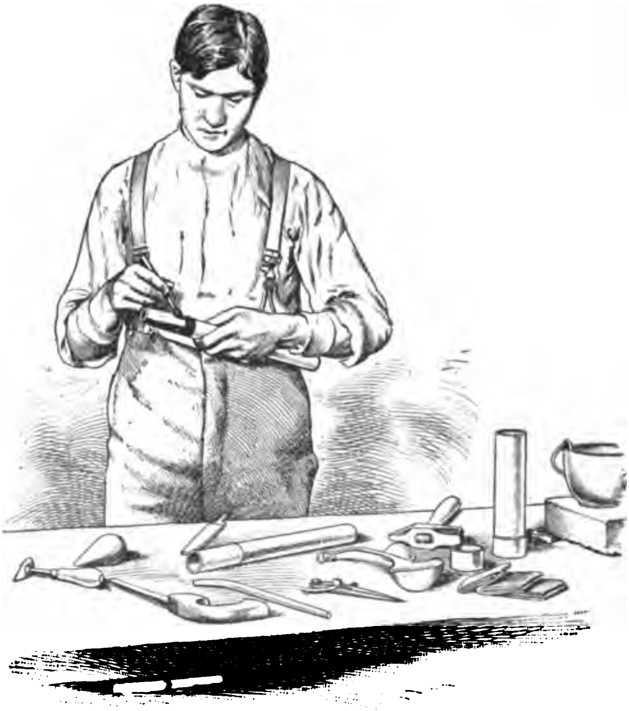


FIG. 36

53. In Fig. 37 the plumber is shaving the male end of the pipe. The female end is set up on a brick so that the soil may be dried by the heat of the fire. The total length of the joint when finished is supposed to be about $2\frac{3}{4}$ inches, and, as the male end slips in $\frac{1}{4}$ inch, the length of the cleaning that the plumber is shaving in Fig. 37 should be $\frac{2\frac{3}{4}}{2} + \frac{1}{4} = 1\frac{5}{8}$ inches. Great care must be taken to avoid skipping any part and leaving streaks uncleaned, for the solder will not adhere to these streaks and they will ultimately become small channels for leakage when the joint is subjected to water pressure. After the male end is shaved, the plumber takes a little tallow and rubs it over the newly cleaned surface to prevent its tarnishing before he is ready to wipe,

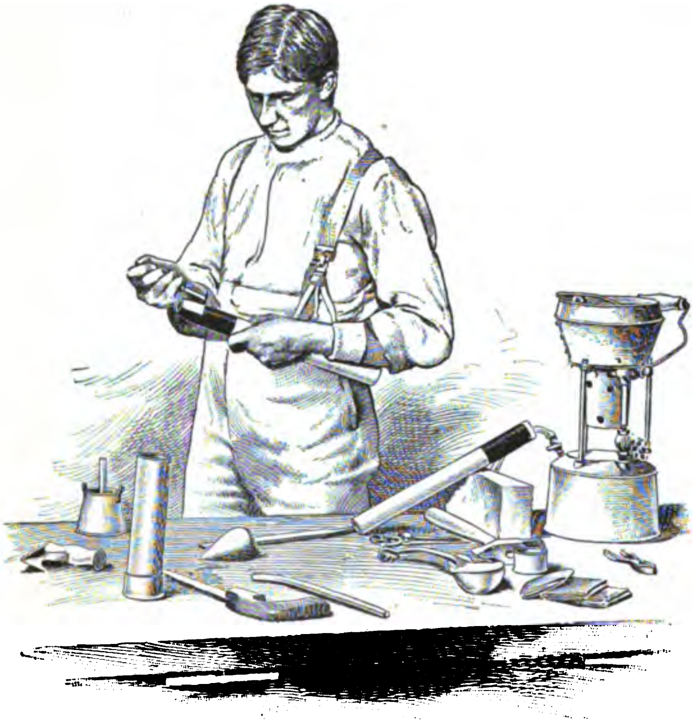


FIG. 37

and also to act as a flux when he is wiping the joint. If there is a fin inside the nose of the male end, it is now cut off with a pocket knife or with the blade of the shave hook. By the time the male end is shaved and greased, the female end is dry, so the plumber proceeds to clean this in the same way, making it only 1⅜ inches long, instead of 1⅝ inches. This brings the edge of the female end in the center of the exposed total cleaning and thus in the center of the proposed joint. After the female end is shaved and shines all around, the plumber places the shave hook inside the swaged opening and deftly whisks it about once or twice, thus cleaning the cup to a depth of about ¼ inch all around. This allows the solder to sweat into the cup to the extreme tip of the male end. The female end and the inside cleaning are now greased, and the two ends are ready to be joined together by a wiped joint.

54. To facilitate wiping, the plumber places four bricks as shown in Fig. 38. The two pieces of pipe are laid in a straight line on these bricks in such a way that each piece is supported by two bricks, which, of course, brings the joint somewhere about midway between the two inner bricks. The object of placing the bricks on edge is to allow a space of 4 inches under the joint, which is plenty of room for an ordinary hand. If the bricks were laid flat, there would be a space of only 2 inches under the joint, and this is too small. Common bricks are 8 in. × 4 in. × 2 in.

55. After the pipes are lined up true, and the cleaned ends are pressed together so tightly that they form an almost water-tight connection without solder, the plumber immediately **fixes the joint,** which means that he fastens the parts to be joined so that they will not move while he is wiping the joint. Experienced plumbers always fix their joints perfectly rigid, and when they are wiped they never leak. In order to suggest means of fastening the pieces of pipe, two different methods are illustrated in Fig. 38.

After the plumber underpinned the bricks with slivers of wood to prevent their rocking, he weighted the pipe next to his gasoline fire-pot with a piece of old lead water pipe weighing about 8 pounds and an old lead pot piece of about the same weight. These made a load of about 16 pounds, which is quite sufficient to hold that pipe steady, provided it is kept from rolling on the bricks by a rasp or file wedged in at each side. The other pipe, however, he steadied by pouring two bands of solder over it in such a manner that the abutments of these two little bridges might bear on the two bricks at the left, as shown. This is a quick, lazy, inefficient plan of fixing, which nearly always injures the pipe when the bands are removed.

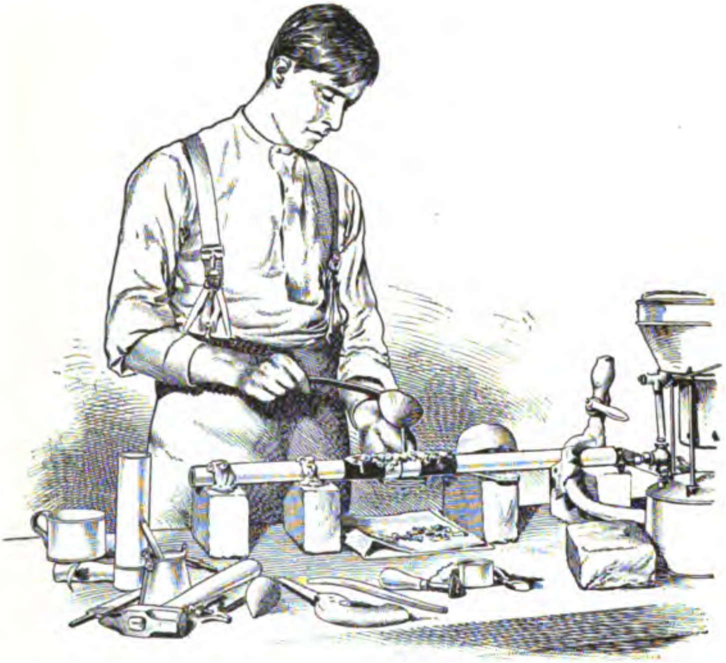


FIG. 38

56. Now the pipe is fixed. The plumber tries to shake it, but it does not move, so he lays an old newspaper under the joint, warms his wiping cloth by the fire, and stirs up the molten solder with his ladle. The solder pot was put on the fire about 3 minutes before he commenced to fix the joint. Knowing the necessity for having good solder, and knowing the trouble that would undoubtedly follow should the metal be foul or defective in any way, the plumber stirs the molten mass until all the lead and tin, of which the solder is entirely composed, are so thoroughly intermixed as to form a uniform composition throughout the entire depth of the pot. He then pours a little of this solder on a brick having a smooth, level surface, producing a disk of molten solder about the size of a silver dollar, which shines like mercury until it begins to set, when it assumes a whitish steel-gray color. But on the surface and surrounded by this color are some four or five small silver-like spots about $\frac{1}{8}$ inch in diameter, which indicate that the solder is good.

57. Everything being now ready and the wiping cloth warm, the plumber commences to pour on the solder, using the ladle and wiping cloth, as shown in Fig. 38. Lead melts at about 626° F., and the solder in his ladle is probably about 800° F., so he must be very careful or he will melt a hole through the pipe and fill the bore with solder. To avoid this, he moves his ladle to and fro along the pipe and slowly pours the hot metal on the soiling as well as on the cleaning. In this way he does not pour twice on the same spot before the heat in that spot is absorbed by the pipe. As he continues to pour on top, some surplus metal runs over the sides and falls on the newspaper, which keeps it from contact with the dirty bench. But his left hand holds the wiping cloth under the joint. This cloth catches some falling solder, which he occasionally pushes up against the under side of the joint to warm it. Of course the plumber hollows his cloth and makes it like a saucer, so that the molten metal will stay there.

58. There are two prime objects aimed at in pouring metal on a joint: one is to properly heat the joint and thus thoroughly tin all the cleaned surface before beginning to wipe for a finish; and the other is to have enough metal on to properly form and finish with. The plumber, therefore, is compelled to lift up the surplus metal periodically and place it on the top, as shown in Fig. 39; otherwise, the top would soon be bare and overheated, while the bottom would be overloaded with cold solder. This action rubs the plastic metal against the cleaned surfaces and tins them, besides producing a nearly uniform temperature all over the joint.

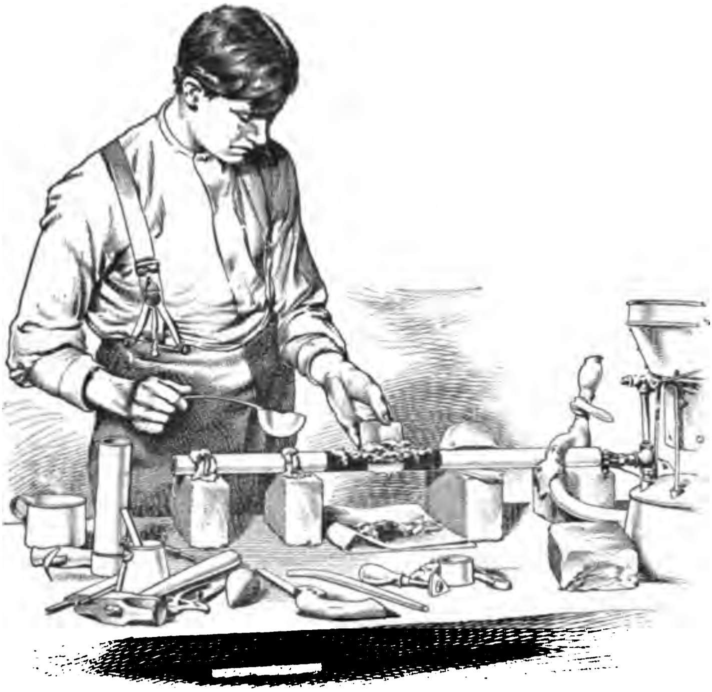


FIG. 39

When enough heat has been applied to cause the solder to slide down and tend to fall off the joint in spite of the operator, and when there is more than enough metal to form the joint, the plumber immediately lays down the ladle and commences to shape the joint with his cloth. He must move his hand quickly, for the metal slides down rapidly and will not wait for him. He must work it up, and at the same time find the edges of the cleaning and form a rough outline of the joint. He must knock off all solder that has set on or near the wiping, so that it will not interrupt his movements. He must guard against the metal falling off the bottom while he is working at the top. In fact, he must look out for a dozen or more things at the same time that are all liable to happen during the few seconds he has to wipe the joint after he lays down the heat-giving ladle. Then, when everything is "just so," he curves the cloth and swings it around the joint—first one way, then the other, as shown in Fig. 40. Before you can realize that the joint is now formed, he draws his cloth neatly over the top, as shown in Fig. 41, to remove any mark left by the swing. With a sharp twitch of the cloth all surplus material is whisked neatly off, and the joint is finished.

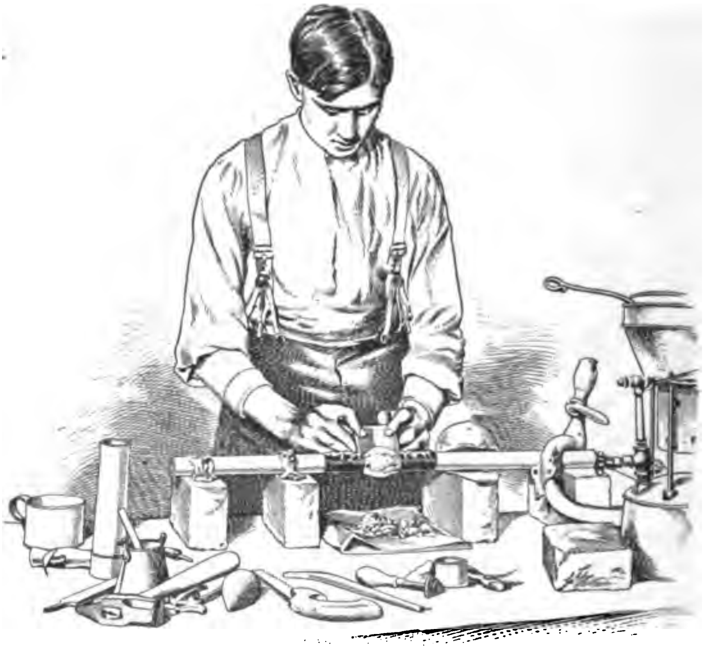


Fig. 40

59. But this is not all, for if he left it to cool off slowly, the tin, whose temperature of fusion is much lower than that of the lead, would percolate through the joint and fall off the bottom in drops, leaving a coarse, chalk-like porous joint with a deep hole in the bottom and a long, sharp-pointed teat hanging from the side of it like a miniature icicle. The hole in the bottom will finally cause a leak. To avoid this, the plumber instantly drops the cloth after making the cross-draw shown in Fig. 41, seizes a looking glass, holds it under the joint to see how it looks on the bottom, and at the same time blows a strong, fine spray of water all over the joint, as shown in Fig. 42, before a single drop of tin has had time to form at the bottom. This spray rapidly chills the joint and instantly solidifies its outer surface. The wiping of the joint is now finished, but it must be allowed to cool for a few minutes before disturbing it; otherwise it may crack or break apart, and the whole operation would have to be repeated.

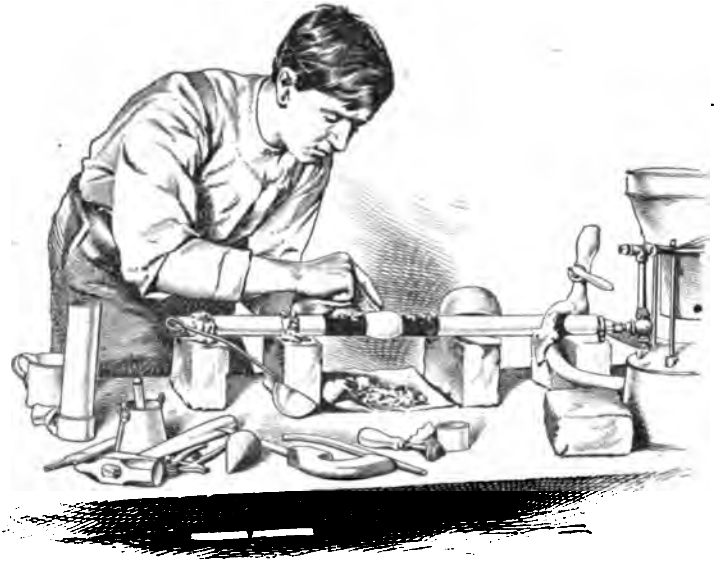


FIG. 41

60. Fig. 43 shows the correct form of a well-made joint. It is uniform in thickness all around. There is neither too much nor too little solder on the joint at any place. A good thickness is over the middle of the joint, and the solder tapers neatly down to the edge of the cleaning. No solder overlaps the soil, and no part of the cleaning is exposed.

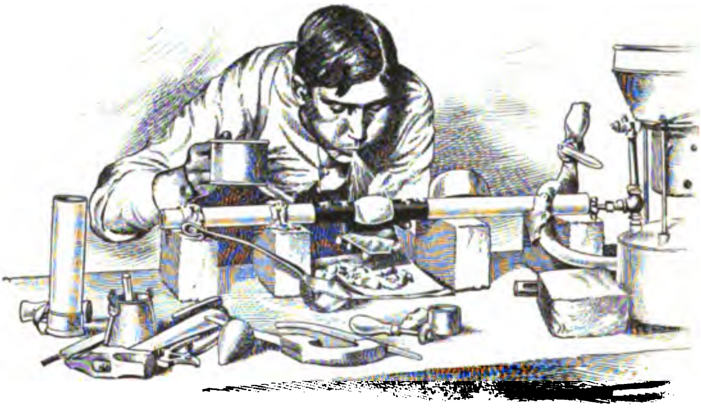


FIG. 42

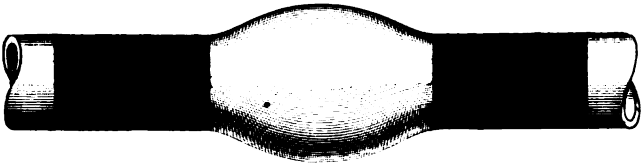


FIG. 43

WIPING A CONCEALED JOINT

61. In Fig. 44 is shown the manner of wiping a joint in a concealed place, the joint in the pipe being out of the sight of the workman. This is done by placing a candle *a* so as to illuminate the back of the pipe *b*, and two mirrors *c* and *d* so as to reflect the image of the pipe. The formation of the joint must be governed mainly by the feeling of the solder while working.

Care must be taken in doing this kind of work to spread the solder well over the soiled parts of the pipe, as otherwise a hole may be burned through the top of the joint. Solder will then enter the pipe, as shown at *e*. Paper should be spread underneath the pipe to catch the surplus solder that is sure to fall off in such work, as shown at *f*.

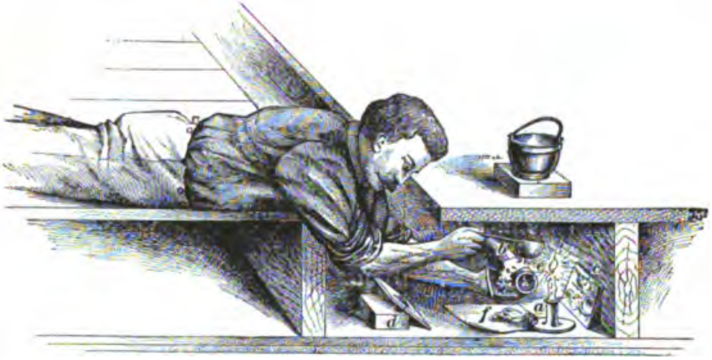


FIG. 44

62. Joints in large horizontal pipes may be wiped in several heats, or two men may operate simultaneously, one on each side. The open ends of the pipe are first closed to prevent a draft of air through it, so as not to convey heat from the joint to the outer atmosphere. Molten solder is then carefully poured on the shaved ends until enough adheres to form the joint. The temperature of the pipe near the joint and the solder on it is then raised to the melting point of the solder by a gasoline torch. The torch flame is then suddenly withdrawn, and the now plastic solder is easily formed into the proper shape. Should the solder begin to set before the joint is entirely wiped, more heat can be applied by the torch. Joints over 4 inches in diameter are seldom found in modern house plumbing.

WIPING BRANCH JOINTS

63. Wiping a T Branch Joint.—The manner of making a common **T** branch joint is shown in Figs. 45 to 54. A hole should first be bored in the main pipe with the tap borer, as shown in Fig. 45, care being taken not to pierce the opposite side of the pipe with the point of the tool. The hole should be much smaller than the branch pipe. The edge of the hole is then turned outwards, as at *a*, Fig. 46, with a bending pin *b*, care being taken not to form an edge *c* projecting inwards. The outwardly turned edge should then be shaped with the turn pin into a cup to receive the end of the branch pipe, which should be beveled and shaved as for an ordinary straight joint, as shown in Fig. 47. This figure also shows the proper form of the cleaning. In describing the boundary line of the cleaning, it is customary to make the distance *a* from ⅜ inch to

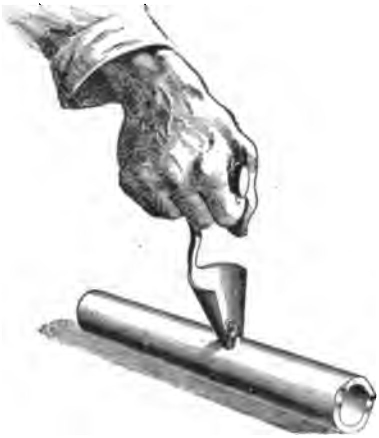


FIG. 45

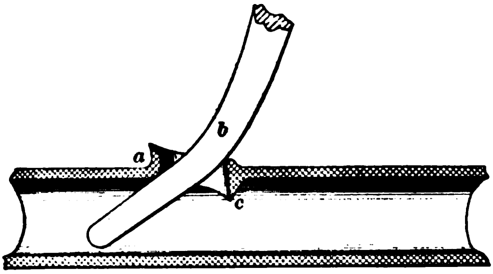


FIG. 46

1 inch on ordinary pipes. The inside of the cupping *b* should be shaved about $\frac{1}{8}$ inch down. If possible, clamps should be used to draw the joint together.

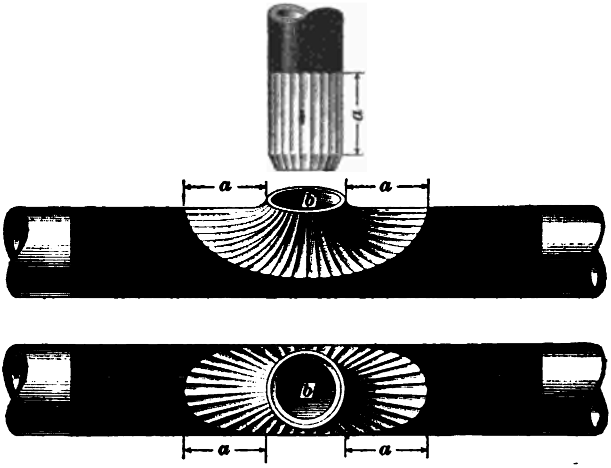


FIG. 47

64. To wipe a **horizontal branch joint,** proceed as in the case of a plain underhand joint, but finish it at the bottom instead of at the top. The finishing is done by drawing the cloth from *a* toward *b*, as shown in Fig. 48, and then immediately cooling the joint with a fine spray.

65. The proper form of a well-shaped branch joint on a lead water pipe is shown in Fig. 49. As an inspection of the illustration reveals, the solder is placed so as to give strength to the joint.

66. In Fig. 50 are given two sections of a branch joint in which the correct and incorrect forms of preparing and wiping these joints are shown.

At *a* the cup in the lead pipe projects too far, and the solder is also misplaced, too much of it being under the cup, where it is not required, and too little above it. The lead protruding through the solder weakens this part of the joint.

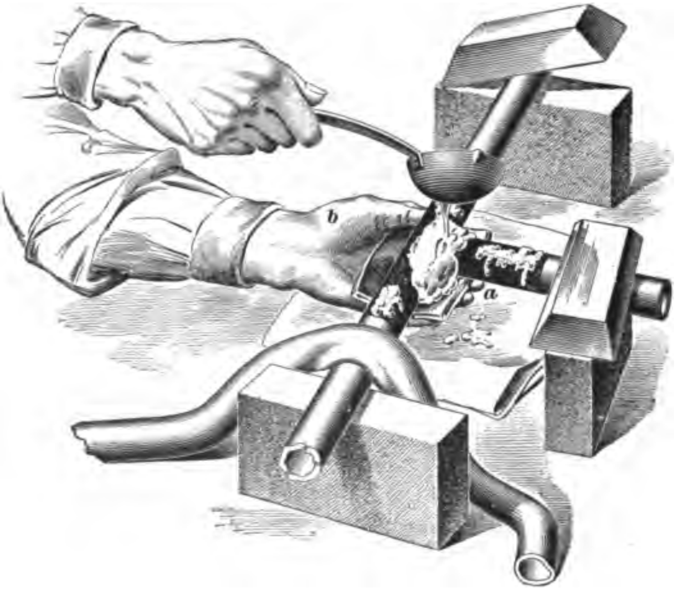


FIG. 48

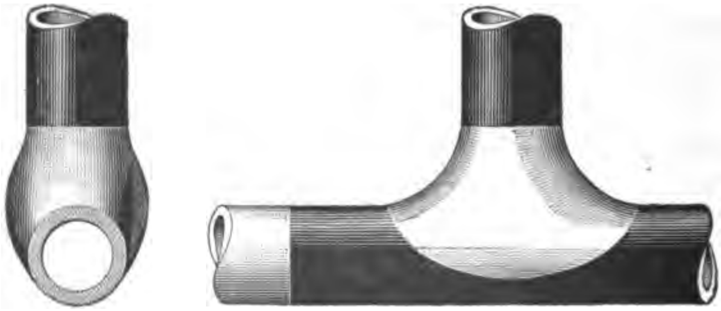


FIG. 49

The side *b* shows how the cup should be fitted, and the form of the solder when finished.

At *c* too much solder is applied, and, consequently, some of it is wasted. This form of wiping conveys the idea of poor workmanship.

The side *d* shows the proper curve that should be given to the solder at this part of the joint. It is stronger than the pipe and has a neat appearance.

At *e* is shown the edge of the lead that has been driven into the pipe during the preparation of the joint. This should have been cut off before the pipes were put together and wiped. At *f* is shown a bead of solder that has flowed inside the pipe through a bad fit in the cup. These should be carefully guarded against.

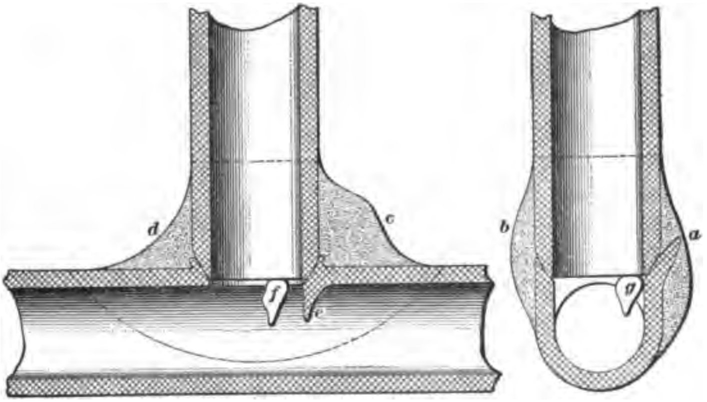


FIG. 50

67. Wiping a Vertical Branch Joint.—The process of wiping a vertical branch joint is more simple and more sure than that of wiping a horizontal branch joint. After the parts are prepared and fixed rigidly, the main pipe, if small, is raised on a small, narrow strip of wood *a*, Fig. 51; molten solder is then splashed on the joint with a splash stick *b*, as shown. It is splashed on gently and in small quantities at first, to avoid burning a hole in the pipe. The speed and quantity is increased, however, and a body of solder

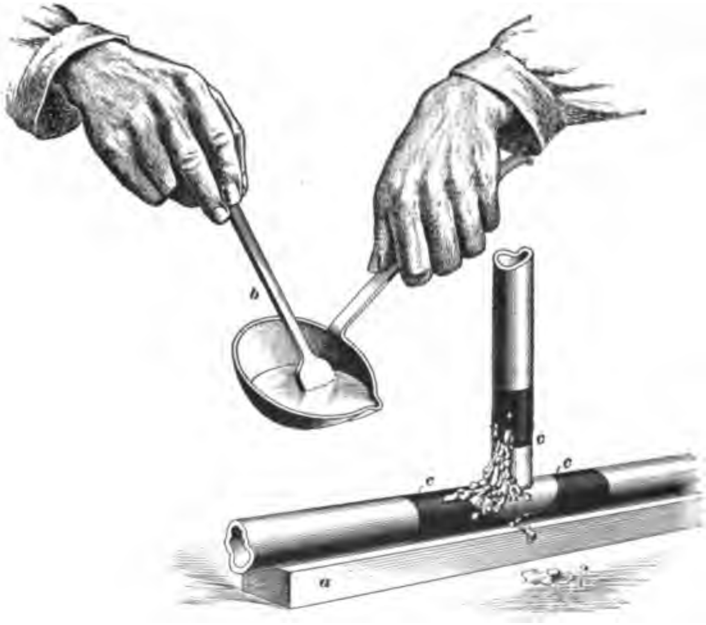


FIG. 51

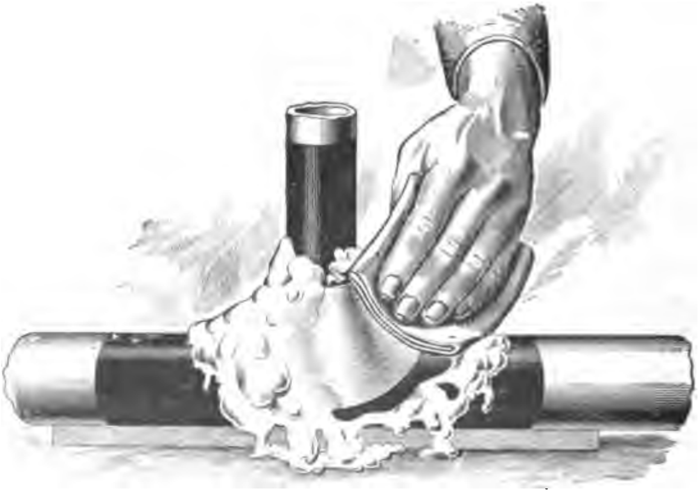


FIG. 52

is soon piled up against the cleaning. The splashing is continued, or metal may now be thrown on the joint from the ladle until the joint is thoroughly and uniformly heated and the mass of solder so soft that it cannot stay up, but slides down on the bench. As the cold pipe conducts heat away from the parts *c*, *c*, *c*, it is necessary to lift the plastic metal on to these places to keep them hot. When the solder persists in sliding off the parts *c*, *c*, *c* and when considerably more metal is on the cleaning than is required to finish the joint, the plumber takes a wiping cloth and wipes the metal into the proper form, as shown in Fig. 52. A joint of this description is usually finished by drawing the cloth down the concave curve *d*, Fig. 50, on to the top of the horizontal pipe.

68. On large pipes, if the operator cannot accomplish the wiping before the solder begins to set, a tank iron is often used, as shown in Fig. 53, to maintain the proper heat. The iron and the cloth are used alternately, the former to melt the solder and the latter to work it into shape before it sets again, or a gasoline torch may be used instead of a tank iron.

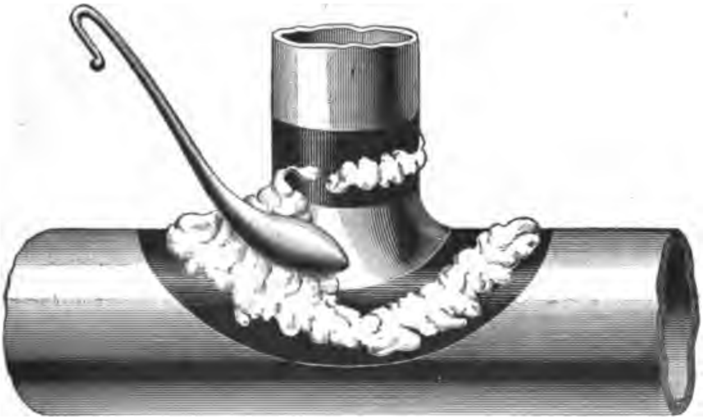


FIG. 53

69. The male end of a large branch joint is liable to slip into the opening when the joint is heated. To prevent this, it is advisable to slit the edge, as at *a* in Fig. 54, in two or more places and then to drive these projections down outside the cupping, as at *b*, when it is feared that the weight of the branch may cause it to slip into the horizontal pipe.

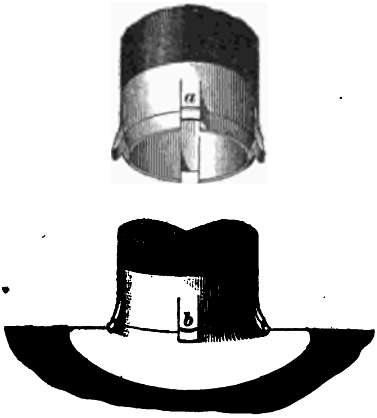


FIG. 54

70. Wiping a TY Branch Joint.—In Fig. 55 is shown a **TY** branch joint. This form of joint should always be wiped on waste pipes. The arrows show the direction of the flow of the water. A common right-angled branch joint does not permit the waste water to flow away with sufficient freedom. The waste

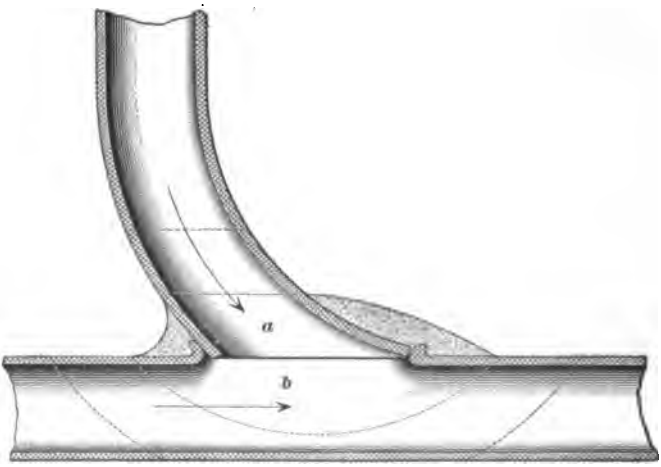
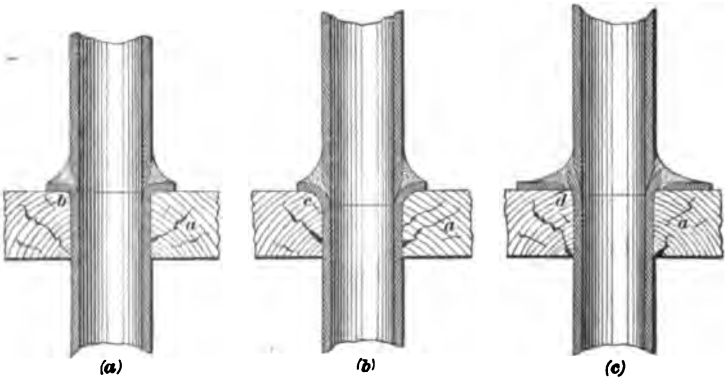


FIG. 55

water is apt to back up and leave deposits of grease and refuse that eventually choke the pipe. Joints like this are usually wiped upright, care being taken to fit the pipe *a* so that it cannot slip into *b* while being wiped. In wiping this joint, particular care must be taken to get up a good heat at the acute angle to the left of the joint. This angle should be wiped first with a small cloth; then a large cloth may be used to wipe the remainder.

WIPING FLANGE JOINTS

71. The **flange joints** shown in Fig. 56 are made by flanging the end of the lower section of pipe over the board *a*.



(a) (b) (c)

FIG. 56

The upper section is beveled and prepared as for an ordinary joint. The solder is applied with the ladle and is wiped to the shape shown with a thick cloth.

The section (*a*) shows a square corner at *b* that should be avoided; the corner should be rounded, as shown in section (*b*) at *c*.

When a heavy weight is to be borne by the flange, it should be reenforced by means of a lead ring or flange *d*, as shown in section (*c*). This should be shaved on the top and soiled on the outer edge and bottom, and must be laid on the board before the pipe is flanged over. Care must be taken that the flanged part of the pipe is thoroughly tinned before proceeding to wipe. When making flanged joints against finished walls or on floors, the woodwork should be protected by sheets of thick paper, as otherwise the hot solder will scorch or disfigure it. The flanges of sections (*a*) and (*b*) are liable to be thinned too much or even split in flanging them over on the board, and on account of this these joints are usually made too narrow. When a separate flange or ring, as shown at (*c*), is used, a wider and much neater joint is obtained. Only this latter form of flange joint should be used.

MISCELLANEOUS EXAMPLES OF WIPING

72. Wiping a Ferrule to a Bend.—A 4-inch brass ferrule is usually wiped on the end of a 4-inch lead closet bend, the wiping being done on the bench in an upright manner; 2-inch and 3-inch ferrules are more commonly wiped in a horizontal position. To prepare a 4-inch lead bend for being wiped on a straight brass ferrule, the ferrule *a* is laid alongside of the bend, as shown in Fig. 57, allowing the end of the bend to project fully ½ inch beyond it. The rings *b* and *c* are then scribed around the bend, *b* being ½ inch below and *c* 1 inch above the end of the ferrule. The space between *b* and *c* is then shaved clean, and the part between *c* and *d* is coated with soil. This distance is about 3 inches. The cleaning is then greased with mutton tallow to prevent oxidation, and the

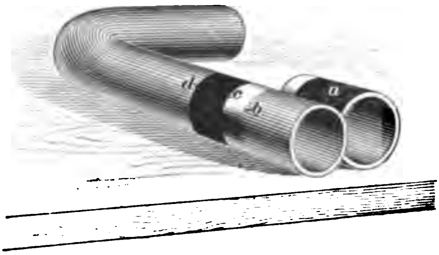


FIG. 57

ferrule *a* is slipped over the end of the bend, like a sleeve. The ferrule is now held in such a position that the width of the exposed cleaning on the lead bend plus the width of the exposed part of the tinning on the ferrule is about 2 inches. The end of the lead bend is then flanged over the end of the ferrule to keep it firmly in its place. The joint is now ready for wiping.

It is not as necessary to have this joint rigidly secured as it is with many other forms of joints, because there is no danger of cracking the joint if the pipe should wabble during the process of wiping, or even after it is wiped and before the solder has become hard.

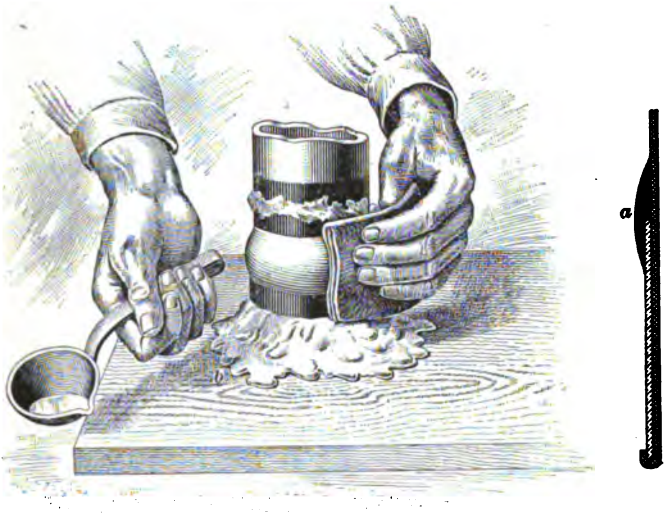


FIG. 58

The molten solder is usually poured on this joint direct from the ladle, but if its temperature is higher than, say, 650° F., it is advisable to commence by splashing the metal on the cleaning with a splash stick. At a temperature of 650° F., molten lead will have a very dull red color, just visible in a *perfectly dark room*, and will just char a dry pine stick without igniting it. When sufficient metal has been splashed on to entirely cover the cleaning, the heat may be got up by pouring the remainder from the ladle. When the heat is up, that is to say, when the ferrule and the lead bend are so hot that the metal slides off the cleaning, the plumber takes the wiping cloth in his left hand and draws up the plastic solder so as to obtain a good body on the joint, and then he begins to wipe.

Since the top of the joint usually sets before the bottom, it is customary to wipe all around the top edge first, then all around the bottom edge, finishing as shown in Fig. 58. Care should be taken not to leave too much solder at *a*, since it will interfere with the calking operation when joining the brass ferrule to an iron drain or soil pipe. The waste solder at *b* should be detached from the work before it becomes set. If it sets before it can be removed, a hot iron may be used to melt it. A sheet of paper should be laid under the joint to catch the solder and prevent its being fouled by any foreign matter on the bench.

73. There are other ways of securing brass ferrules on lead pipes or bends, but they differ with the shape and size of the ferrule. The method described and illustrated here is recognized as the best when straight cylindrical ferrules are used.

74. Wiping Upright Joints.—When wiping large upright joints, the heat may be applied by a tank iron, a blowpipe, or a gasoline torch, as circumstances may require. Two or more men may be employed on the same joint at the same time in order to finish it in one heat, or one man may do it in several heats. If the means at hand for heating the joint are sufficient, there is no more difficulty in wiping large joints than small ones.

75. When joints are to be wiped on upright pipes that are already in position, a collar should be attached temporarily to the pipes directly under the joints, so as to catch the solder and to raise the temperature of that part of the pipe under the joint.

In Fig. 59 is shown a piece of lead pipe with a collar *a* in position, which is supported by a cord *b* tied around the pipe. The collar should be cut to a pattern similar to *c*, so that when it is formed around the pipe, the points *d*, *d* can be doubled over and locked together, as at *e*, to prevent its spreading apart when the solder falls into it.

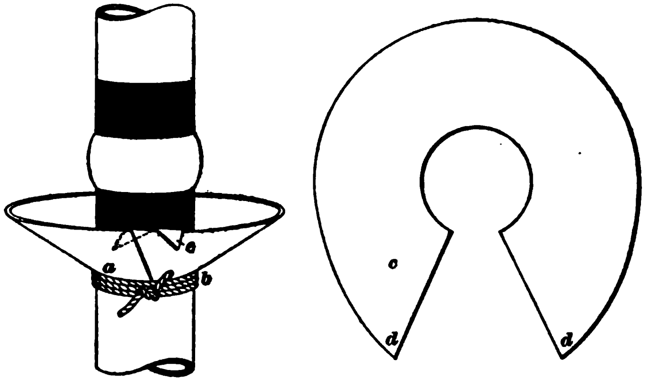


FIG. 59

These collars are best made of sheet lead, as this metal is very pliable and has no spring to it. The inner surface of the collar should be coated with soil to prevent the solder adhering to it. The same collar can be used repeatedly by simply soiling its inner surface on each application. Paper collars are sometimes used, but they are not so satisfactory.

76. Wiping a Cross.—A **cross** is the name given to a combination of two branches wiped to the same pipe and opposite each other, as shown in Fig. 60. The main line *a* is tapped and cupped, as shown in (*a*), to receive the two branches *b*, *b*. This joint is wiped in a horizontal position and is as easy to wipe as a common **T** branch, provided the solder is of the best working quality and that the soiled parts are well heated before the wiping is commenced. The method of preparing the parts is shown in Fig. 60 (*a*), while the proper form of the finished joint is shown in (*b*) and (*c*). This combination joint is wiped with one heat.

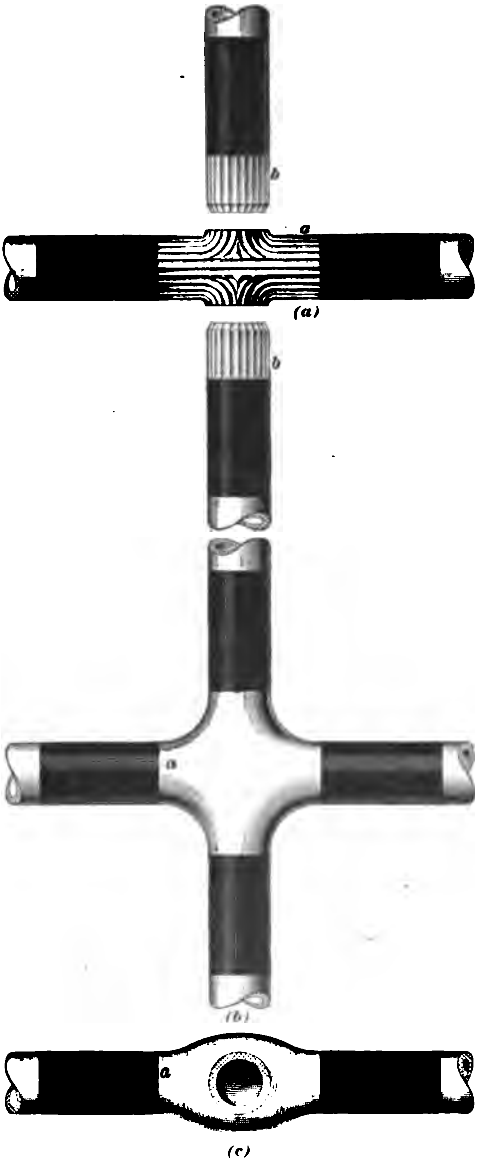


FIG. 60

77. If the main pipe is much larger than the branches, the latter are wiped separately. If the wipings are quite close together and there is a liability of molten solder running on to the joint already wiped, it should be protected with paper pasted over it, as shown at *a* in Fig. 61. This figure also shows a simple method of fixing the pipes. The main pipe is fixed down on the bench and prevented from shifting by a pair of dividers *b*. The branch pipe about to be wiped is held steady by a piece of pipe *c* bridging over and resting on its crest. A sheet of paper should be placed on the floor to catch all solder that drops while the branch is being wiped.

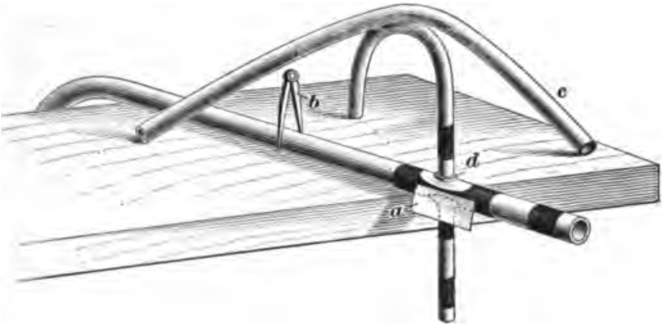


FIG. 61

78. Wiping a Solder Nipple.—Connections between pipes that are united by solder to other pipes joined by screw threads may be made by means of a solder nipple, as shown in Fig. 62. The nipple *a* is made of brass and is joined to the lead pipe *b* by a wiped joint *c*, as shown; the opposite end is provided with an internal or external screw that is adapted to connect with a threaded pipe or to a fitting, as at *d*. A square or hexagonal shoulder *e* is cast on the nipple to facilitate screwing up. The joint should be wiped before the solder nipple is screwed to the pipe, if possible, because the iron conducts heat away from the nipple

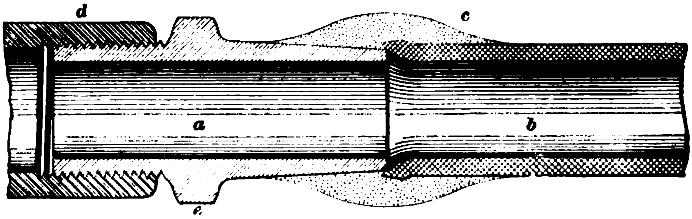


FIG. 62

too quickly and the solder is liable to set at *a* before the plumber has time to finish wiping. If such a nipple must be wiped in place, it is advisable to heat the iron pipe with a gasoline torch before commencing to wipe the joint.

79. Wiping on Trap Screws.—Brass trap screws, or screw-caps, are wiped on lead pipes, traps, etc. by first boring a hole with the tap borer and working it up with the bending pin, and then cupping it with the turn pin until it fits the ring *a* of the trap screw, as shown in Fig. 63. The ring being tinned outside, soiled on top and inside the thread, a tissue-paper plug *b* is packed in to close the opening. The lead is then soiled, shaved, and greased. The ring is now tightly driven in so that it will not work loose while being wiped, and yet not far enough in to form an obstruction to the flow of water in the pipe. The joint is then wiped.

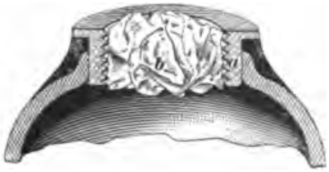


FIG. 63

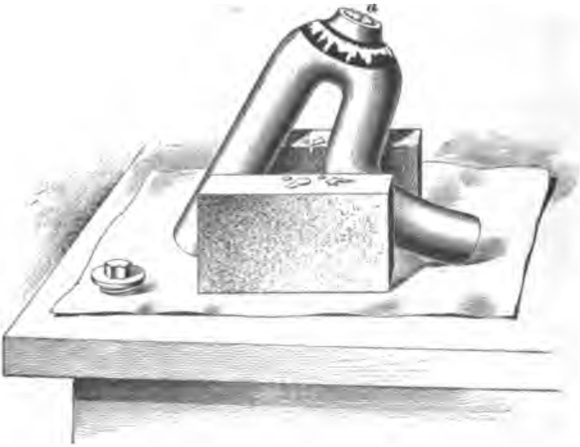


FIG. 64

80. Fig. 64 shows a trap held up by two bricks. The trap screw *a* has just been wiped in, and the paper plug is still in. It should be removed after the loose solder is picked up and remelted. This lapse of time will give the wiped joint an opportunity to set before the paper plug is pulled out.

HOLDING PIPES WHILE WIPING

81. Fig. 65 illustrates a good method of fixing lead pipes to wipe on a stop-cock. The pipes are laid on bricks and weighted with pieces of old pipe, solder ingots, or any other convenient heavy bodies. To prevent the cock from turning while the joint is being wiped, some melted solder is poured over each joint, as shown. One joint is wiped, and after it has set, but before the cock has cooled off, the other joint is also wiped. Straight valves are fixed in the same way.

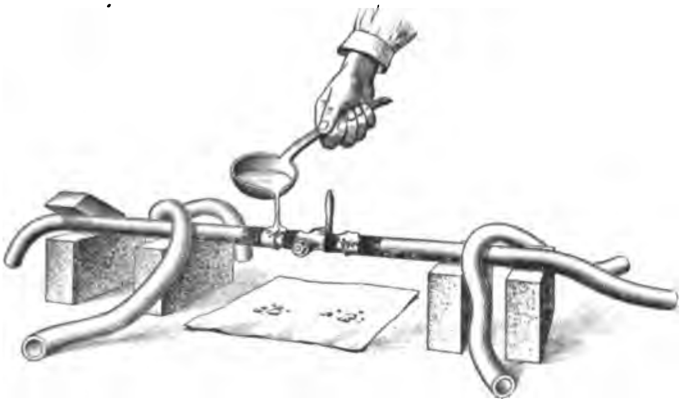


FIG 65

Special joint-fixing clamps can be purchased for the purpose of fixing joints, but plumbers appear to prefer bricks and weights. They can be found on any job and are more rigid than most joint-fixing clamps.

82. Fig. 66 shows a simple method of **fixing a common sink bibb** previous to wiping it on to a lead water pipe, leaving an air chamber *a* above the bibb. A pair of compasses holds the pipe steady. The bibb is pushed into the cupping and the lead is driven tightly up against the shank of the bibb. A piece of lead pipe *b*, bent like a horseshoe, rests on top of the bibb, as shown. This is not a very secure fastening, but if care is exercised in wiping, there will be little danger of the bibb falling down, for the brass shank expands and tightens itself in the pipe when heat is applied. The end *c* of the pipe *a* is cut on the bevel, soiled outside, scraped and greased inside, and a soft paper plug is pushed into the pipe about ½ inch to prevent solder from running too far in the pipe when the end is being wiped over.

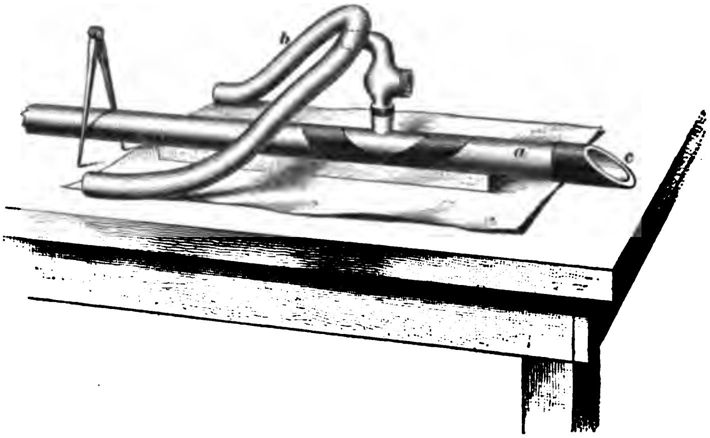


FIG. 66

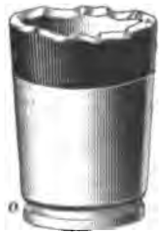


FIG. 67

83. When the bibb is too short to allow hand room, if a lead weight like *b*, Fig. 66, is used, it is a good plan to file a notch or groove around the shank, as shown at *a*, Fig. 67. The lead edge of the cup is tightly driven into this groove with a chisel and holds the bibb steady without a support.

84. Fig. 68 shows a quick and simple method of fixing a spud or solder nipple. The brick *a* holds down the wooden plug *b* and pushes the spud toward the pipe. If *a* were placed on top of *b*, the brick *c* might rock and allow the joint to open a little, which would permit solder to flow inside the pipe.

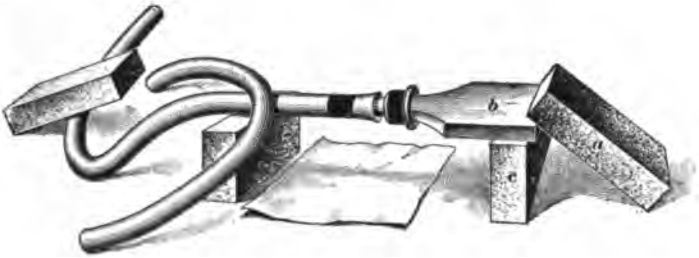


FIG. 68

LEAD WORK

WORKING SHEET LEAD

LINING TANKS

INTRODUCTION

1. The inside of a house tank intended to contain water for domestic purposes is usually lined either with sheet copper or sheet lead. In small tanks the bottom and two sides can usually be formed from one piece of sheet lead; the two ends are separate. In the corners where the seams must be made, the edges of the lead are usually butted together and a seam wiped. These corner seams are easily wiped when the tank can be turned up on its ends, because then the seams are horizontal. In large tanks that cannot be turned over, more difficulty is encountered, as the corner seams must be wiped in a vertical position. If large tanks are carefully made and free from irregularities and angles, the ends of the sheets may be butted at the seams; but if the corners are irregular, it is customary to lap the seams, allowing ½ inch for lapping at the back, and to shave the sheets in position.

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DETAILED INSTRUCTIONS

2. Dimensions.—The following 23 illustrations show how a common house tank of about 1,000 gallons capacity may be lined with sheet lead. The inside dimensions of the tank we will assume to be approximately 8 feet long, 5 feet 1 inch wide, and 3 feet 6 inches deep. Fig. 1 shows the tank, which is of the ordinary rectangular form. We will assume that the carpenters have just finished the woodwork; for the sake of convenience in lining the tank, the tie-rods shown on the floor at *a* and the end braces *b*, *b* have not been placed in position.

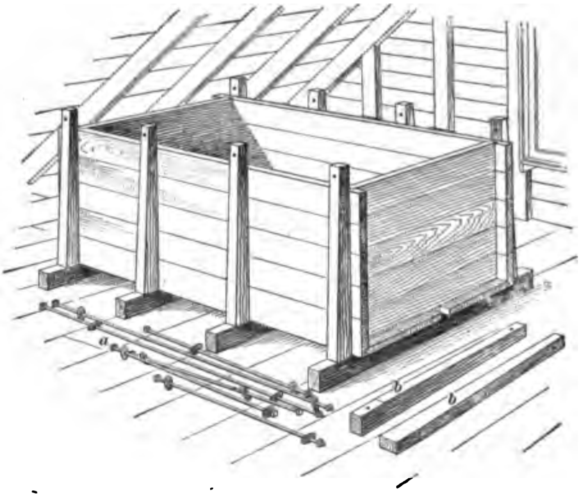

FIG. 1

3. Trying the Corners.—First of all, the corners of the tank are tried with a steel square, to see if they are at right angles. Instead of using a steel square, the two diagonals may be compared; if they are the same length, the tank is square. A convenient means of doing this is to employ two thin wooden rods, holding them together with the hands, as shown in Fig. 2, and applying them to the inside corners, first on top, and then on the bottom, as the tank may have a twist. If the tank is not true, the carpenter should make it so before the plumber commences to line it. We will assume this tank to be nearly true, that is, not more than ⅛ inch out at any place.

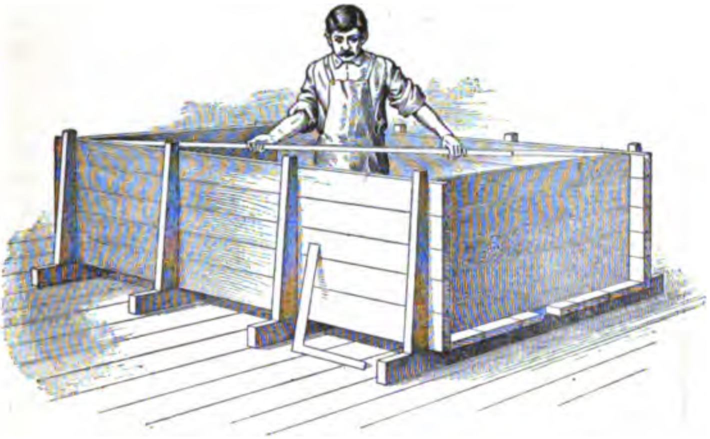

FIG. 2

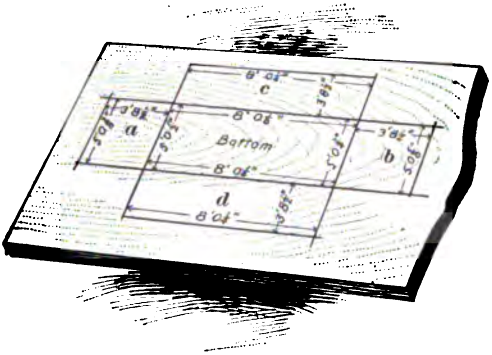

FIG. 3

4. Measuring the Tank.—The next step is to measure the interior surfaces, making an allowance of 2½ inches for the lining to fold over the top, which is 2 inches wide; this permits the lining to be folded down ½ inch on the outside. In order to keep a record of the measurements, it is advisable to make a small sketch on a shingle or other convenient material, and to write on it the dimensions, as shown in Fig. 3. In this sketch, the rectangles marked *a* and *b* represent the ends, and those marked *c* and *d* the sides, of the tank lining. The dimensions should be measured as accurately as possible.

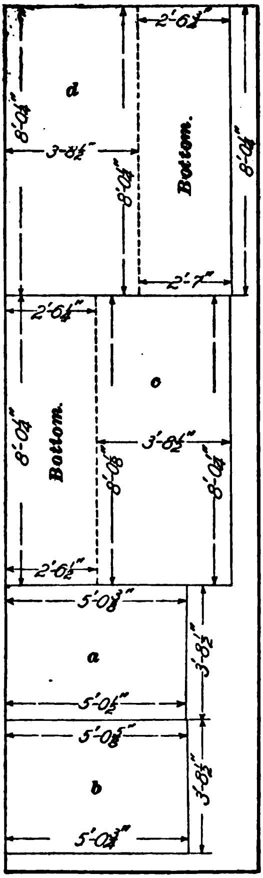

FIG. 4

5. Laying Out.—The sheet of lead is now unrolled on a smooth, flat surface, and the best mode of cutting it up carefully considered. In this particular case, Fig. 4 shows a good plan of cutting up the sheet, the lining being laid out so that seams will come in the corners and along the center of the bottom, and having the pieces small enough to be handled easily. A piece of sheet lead large enough to cover the bottom and the two sides of this tank would be too heavy to handle. The arrangement shown allows the tank to be lined in four pieces, as follows: Two end pieces *a* and *b*, a side piece *c* and half of the bottom, and a side piece *d* and the other half of the bottom.

6. Cutting.—Fig. 5 shows how the sheet lead is cut up with the knife. The plumber runs the point of the knife along the lines made on the sheet, and tears off the small pieces, as shown; the big pieces, however, cannot be thus torn off. They are bent forwards and backwards a few times, when they break off at the knife cut. The sheets are now ready for being prepared for the tank. While the plumber is preparing the sheets, the carpenter should be at work gouging out a groove *a*, Fig. 6, 1½ inches wide and ⅝ inch deep, along the center of the tank bottom, also **bull's eyes,** or **buttons,** *b* on the sides, each 2 inches in diameter and ⅝ inch deep.

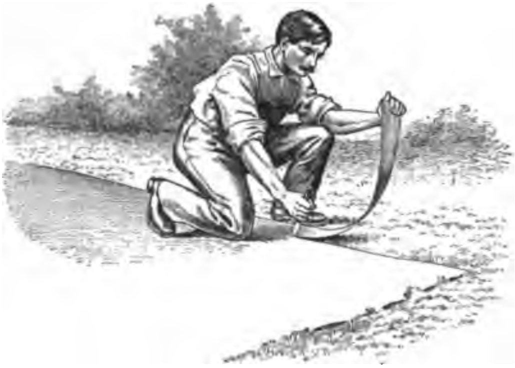

FIG. 5

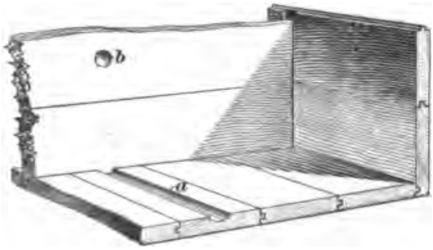

FIG. 6

7. Preparing the Sheets.—To prepare the sheets, the edges first of all are rasped or planed straight and true. The helper then heats the soil pot, while the plumber sets the compasses to 4 inches and scribes a line parallel with the edges of the lead, as shown in Fig. 7. The edge, however, that will fold over the top of the tank is not scribed.

The helper follows up behind the plumber, chalking the surface with one hand and rubbing it with the other. The plumber next neatly paints the chalked surface to the line with soil, as shown in Fig. 8, while the helper dries it by heating the sheet on the under side, as shown. This dries the soil as fast as the plumber can put it on. Too much heat or too sudden an application of the heat will blister the soil. It is necessary, therefore, to distribute the heat by swinging the flame backwards and forwards.

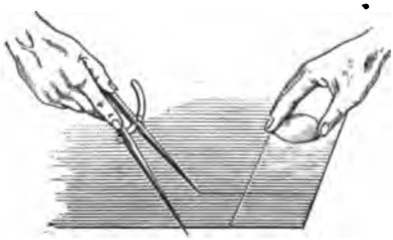

Fig. 7

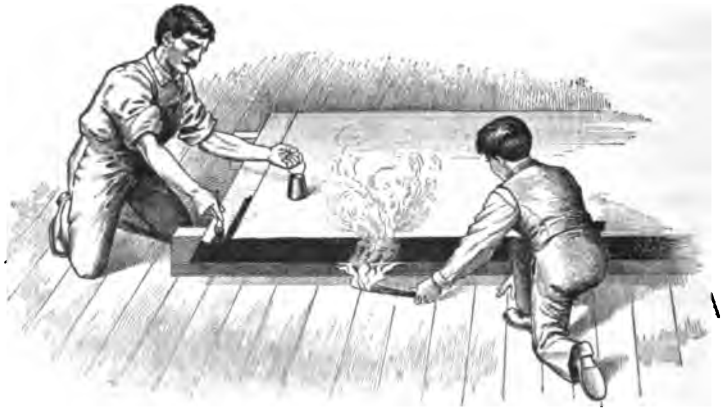

Fig. 8

8. The next step in the preparation is shaving the lead. The compasses, set to about $\frac{7}{8}$ inch, are used to scribe a straight line parallel with the edges to be soldered. This shining line is scratched on the soiled surface and forms the boundary line for the cleaning, or in other words, the edge of the wiping. The dirty skin of the metal is then shaved off to give a bright, clear, metallic surface between the edge of the soil and the edge of the sheet, as shown in Fig. 9, which shows the helper rubbing the surface with mutton tallow before the metal has time to tarnish. If the metal is allowed to tarnish after shaving it, defective seams may be expected in the tank. In shaving the cleaning, it is necessary that no unclean streaks exist; the solder will not adhere to these streaks and a leak may be the result. The edge of the sheet should be beveled with the shaving hook to an angle of about 45° while the cleaning is being performed, so that the edges will be mitered when the sheets are set in position in the tank.

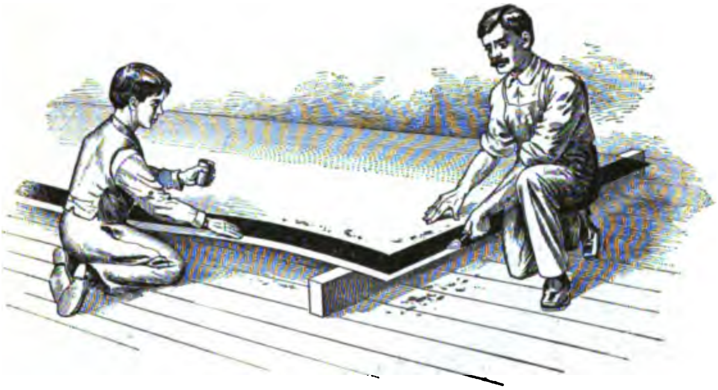

FIG. 9

9. The first part of the lining to be prepared is the sheet *d*, Fig. 4, with half the bottom, because there is an allowance of $\frac{1}{2}$ inch made on the bottom for folding into the groove in the bottom of the tank. The next piece to be prepared is the piece *c*, and then the two ends are prepared and put in the tank after *c* and *d* are secured in position. In bending *c* and *d* (before placing them in the tank), it is necessary to bend them so that the proper amount will fold against the sides and the proper amount on the bottom. Thus, the pieces marked *c* and *d* laid off on the big sheet are to be bent up on the dotted lines shown. These dotted lines represent a chalk-line mark that is struck to mark the angle of the tank. To bend the sheet, the helper lays a plank with its edge at the chalk-line mark. Both men stand on this plank to hold it firmly; both men then lift up the bottom (because it is the lighter part) until it is plumb. The plumber now takes a block of wood and a heavy hammer and sets the lead in against the plank, as shown in Fig. 10, while the helper stands on the latter to hold it in position. This being done satisfactorily, the plank is removed, and the sheet is rolled up both ways toward the bend, when it is ready for lifting into the tank. The process of *bending* is quite generally known to the trade as **breaking up.**

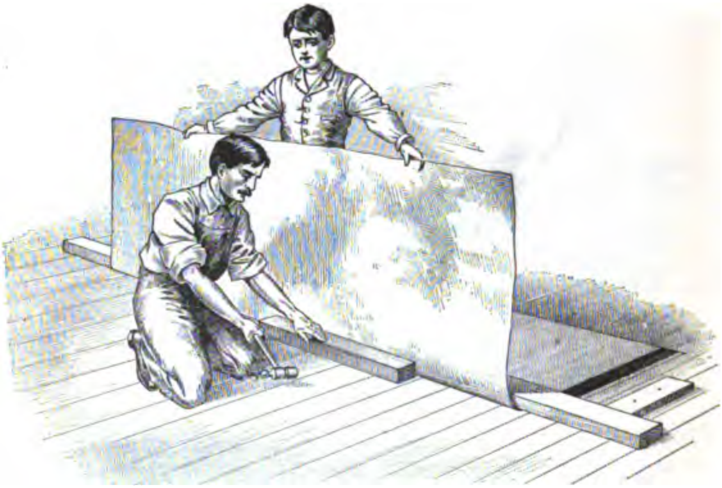

FIG. 10

10. Placing the Sheets.—A convenient way to raise the sheet to the top of the tank is to place two planks against the side of the tank, and then slide the sheet up, removing the planks when it is on top. The men now get into the tank, one at each end, put their arms around the roll, as shown in Fig. 11, and lower it gently into place, pushing it hard against the side as it descends, so that friction will take its share of the load. It is necessary to keep the lead level during lowering, because it is a tight fit, and otherwise may jam against the ends. The sheet being on the bottom, the men push the **break,** as the sharp bend is called, closely into the angle and unroll the bottom part, flattening it. Next, they unroll the side lining upwards and bend it over the top to keep it in place. The lead is then gently beaten against the woodwork with a dresser or flat board, to make a perfect fit. The other large sheet, which forms the other side and the other half of the bottom, is unrolled, prepared, raised, lowered, fitted, and dressed snugly into place in the same manner.

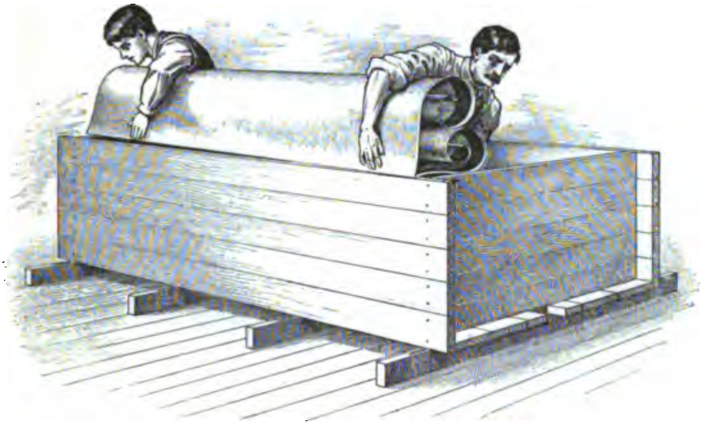

FIG. 11

11. The end pieces are squared, trimmed to accurate dimensions, chalked, scribed, soiled, dried, beveled, shaved, and greased in just the same manner as the first sheet and are put in place and dressed into the corners. There is a difference, however, in the handling of the end sheets, not because they only weigh one-third as much as the large pieces, but because the edges of these end sheets must be a close and tight fit against the edges of the other sheets. For this reason the end sheets are not rolled up and then unrolled in place (unless, of course, they are too large and clumsy to handle), but are simply laid in place flat or nearly so. To facilitate matters, however, and let the end piece go in quite easily, the plumber **breaks its back,** that is, bends it, over a plank, as shown in Fig. 12, before trying to put it in place. This curves the piece in the middle and consequently shortens the distance between its edges and enables it to slide in easily. When in place, the edges are guided into the angles, and the bulge is pressed back against the woodwork. The other end is inserted in the same manner. The helper now dresses the surplus 2½ inches neatly over the top of the tank, a ½-inch margin being bent down over the outside surface. Then he nails down the top with 1-inch or 1¼-inch flathead brass nails, placing them about 6 inches apart. The plumber meanwhile cuts a piece about 6 in. × 14 in. off the scrap lead and makes a flap, shown in Fig. 13, and proceeds to flap, with the flat part, the lining very closely against the wood all over the tank, which smooths the surface. The seams are now securely nailed to the woodwork, with ¾-inch tinned clout nails, to prevent their bulging forwards when the lead is expanded by heat during the wiping process.

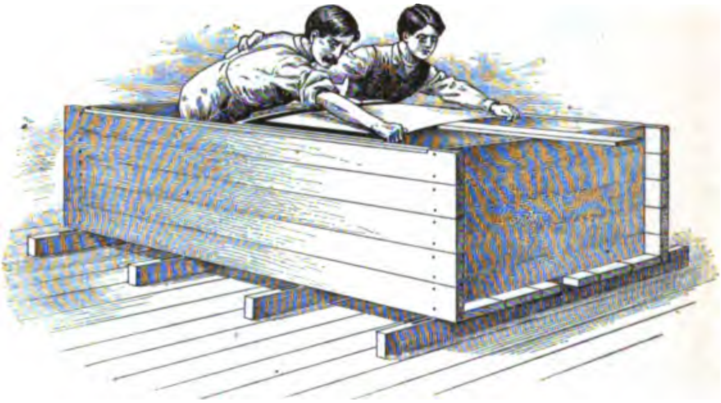

FIG. 12

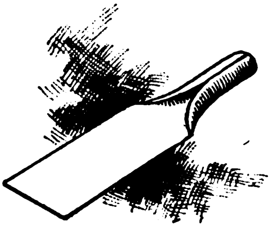

FIG. 13

12. Wiping the Seams. — In wiping this tank, the helper should start two fires, put on two metal pots, and heat three tank irons. About 20 pounds of solder are required for the work. It is customary to figure the amount of solder required for lining a tank by allowing 1 pound to every 2 feet of seam. The length of seams to be wiped in this tank are:

Upright corners	4 × 3′ 6″	= 14 lineal feet
Horizontal corners	2 × 5′	= 10 lineal feet
Flat seam	1 × 8′	= 8 lineal feet
Total		32 lineal feet

The weight of solder actually required $= \frac{32}{2} = 16$ pounds, or fully three bars, but as it is necessary to have more solder in the pot than is actually required for wiping the seams, four bars, at least, should be melted. The tacks used for the seams should be driven in about 2 inches apart, and in such a manner that the edges of both sheets will be snugly and tightly held back against the wood, as shown in Fig. 14. The tack heads must be punched in beyond the surface of the lead; otherwise they may project so far that the solder will barely cover them when the wiping is finished. This precaution of punching takes a little time to perform, but it is time well spent, for the majority of leaks that occur in wiped seams are traceable to carelessness in punching in the tack heads. If the seams are not properly tacked, the hot metal during the wiping process will work in between the lining and the woodwork, where it will cause much annoyance, besides preventing the sheet lead from being beaten back into place after the seams are wiped.

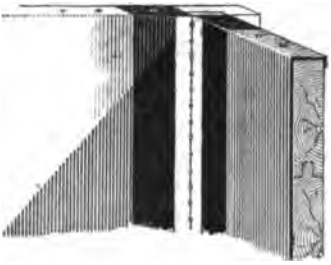

FIG. 14

13. After the corner seams are nailed, the countersunk seam on the bottom is secured in a similar manner. This seam, however, is different from the others, because the edge of one sheet overlaps the edge of the other about ½ inch, as shown in Fig. 15, and 1-inch tacks are used in preference to ¾-inch tacks, for there are two thicknesses of lead for them to go through. Sometimes the corner seams are lapped in a manner similar to this, but the majority of tanks are lined with butted corners, which give perfect satisfaction if closely fitted and properly wiped.

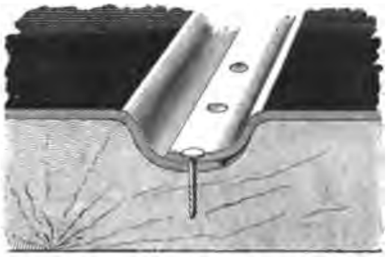

FIG. 15

14. The next step is to find the bull's eyes, or cavities, in the sides and ends of the tank, and then to dress the lead into them. In order to find these cavities now that they are covered with the lead lining, their location should have been taken and the measurements marked down previous to putting in the lining. The lead can easily be driven back into the cavities with an ordinary round-headed hammer or mallet. The lead is secured to the bull's eyes, as shown in Fig. 16, with 1¼-inch brass screws having tinned heads. These support the lining and prevent its bulging inwards. In this tank there is one bull's eye in the middle of each end and two in each side, making six in all. After the bull's eyes are soiled, scraped, and greased the tank is ready for wiping.

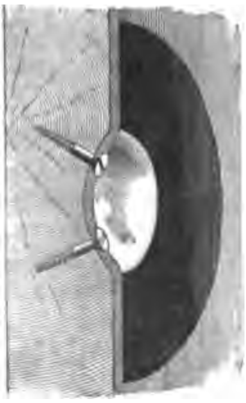

FIG. 16

15. The helper brings up the fire-pots, solder pots, and tank irons, and then opens the attic windows for ventilation.

A **pouring stick** is made by cutting a piece of soft pine to the shape shown in Fig. 17. The plumber picks out his wiping cloth, which is about 2½ inches square and the thickest one in the bag, and lays it on a brick by the fire to soften, for, being soaked with mutton tallow, it is quite hard when cold. Being satisfied that the metal is good, he enters the tank. The helper hands him the ladle, cloth, shave hook, a piece of paper, the pouring stick, two bricks, and finally the metal pot, which the plumber stands on the bricks, the wiping cloth being laid by its side.

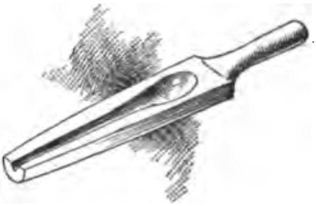

FIG. 17

16. With the pouring stick in his left hand and ladle in his right, the plumber pours molten solder into the angle, as shown in Fig. 18, the stick being used to guide the stream to the desired parts. He does not pour it all on one

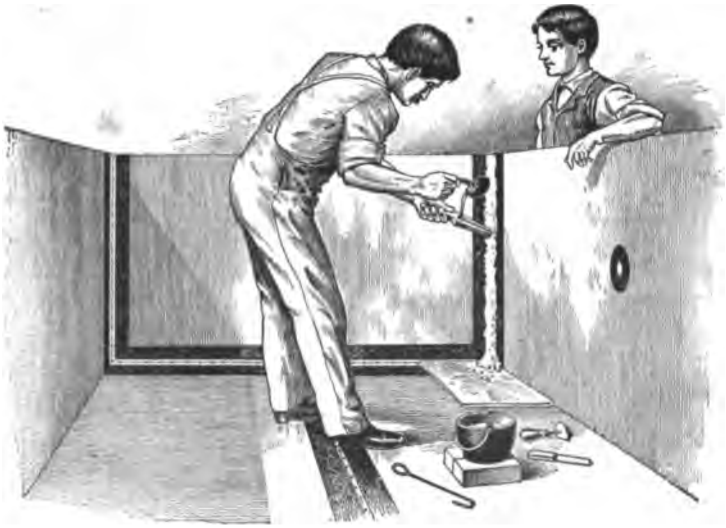

FIG. 18

spot, but spreads it over the entire length and breadth of

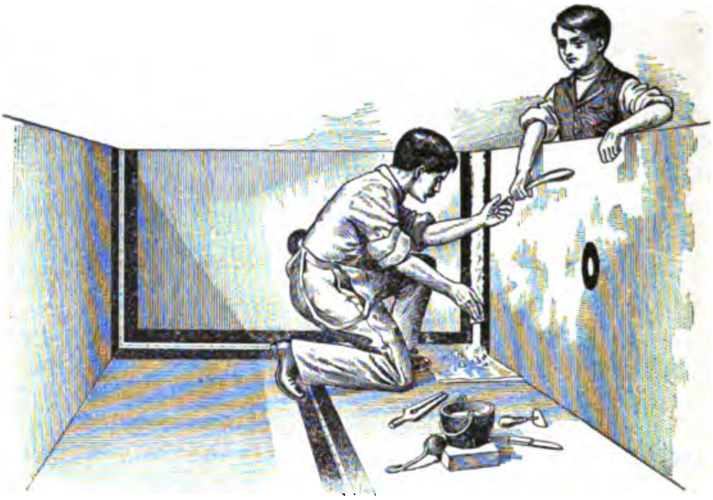

FIG. 19

the vertical cleaning, pouring on more and more until the seam becomes so hot that the solder becomes plastic, and

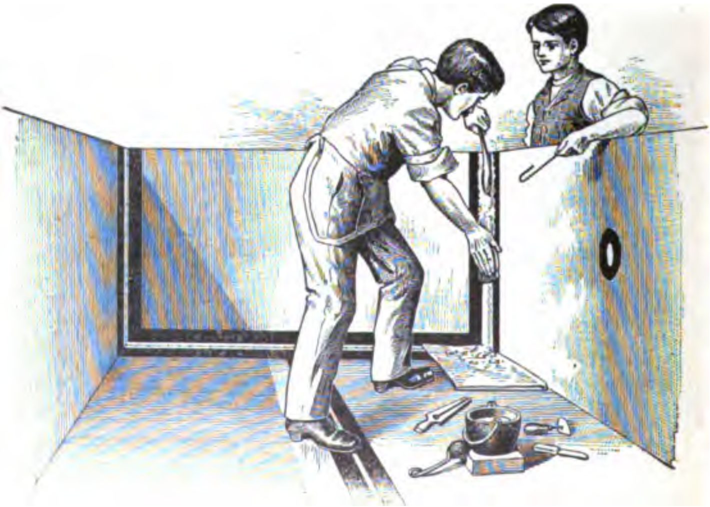

FIG. 20

tends to run down. The helper then pulls a red-hot tank iron out of the fire, cools the handle in a pail of water, and rubs the scales off the red-hot head with the edge of an old file; he then hands the iron to the plumber, who is now busy keeping up the plastic solder, as shown in Fig. 19. The tank iron is rubbed up and down the seam to keep the solder plastic and to thoroughly tin the cleaning. The cloth is used to keep up the viscous mass and push it into the seam, as shown in Fig. 20. This operation must be continued until the seam is thoroughly tinned, which can be determined by the plastic solder clinging to the cleaning.

17. The seam being properly heated and thoroughly tinned, and having a good thickness of plastic solder all over its length from the top of the tank to nearly the bottom, the plumber immediately proceeds to form and finish the seam by wiping down from the top, as shown in Fig. 21, with his middle finger bearing heavily on the center of the cloth to curve it. The tank iron and cloth are alternately applied to the seam, the former to melt the solder and the latter to work it into

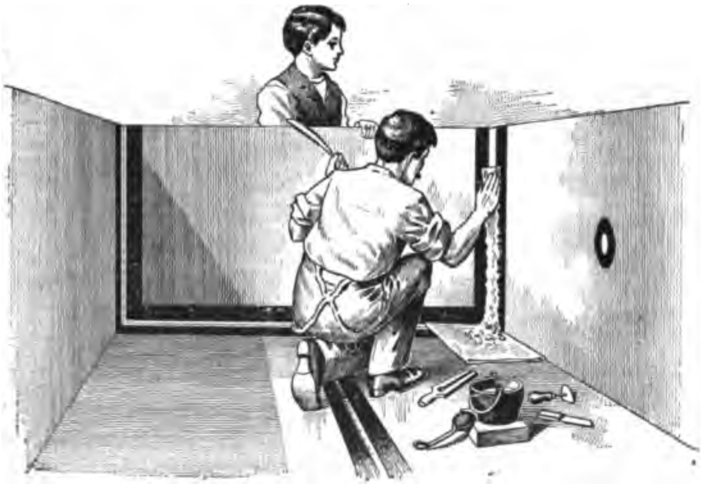

FIG. 21

shape, until the bottom is reached, when the plumber receives another hot iron and returns the cold one to the helper for reheating. The surplus metal from the vertical seam (now wiped) is pushed into the horizontal angle, where it is melted by molten solder being poured on it. The tank iron is then used to keep up the heat, and the cloth to press the solder into the seam and to wipe it into proper shape. The plumber stops wiping when he reaches the intersection of the horizontal end seam with the countersunk seam, where he pastes on a piece of paper, as shown at *a* in Fig. 22.

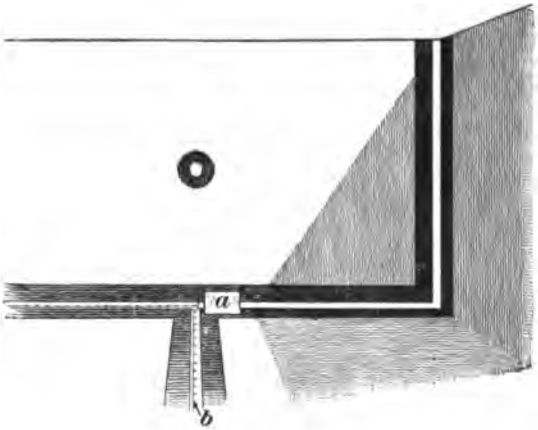

FIG. 22

18. The helper picks up the loose solder and takes away the pot to reheat it; he then hands in the other pot, and the plumber wipes the other corner seam in precisely the same manner as described. But, when he joins the new wiping to the old one, he finds the piece of paper at *a*, Fig. 22, to be very convenient, for it prevents the solder from overlapping the wiping and adhering to it. A neat connection is therefore obtainable. This time he finishes wiping somewhere near *b* on the countersunk seam. The other end of the tank is wiped and finished in a similar manner.

19. The countersunk seam is easily wiped. Molten solder is poured into it until the groove overflows. The tank iron and cloth are used in a manner similar to that already explained. The chief difference lies in the fact that this seam is wiped flush with the tank bottom. The seams being all wiped, the helper picks up the surplus metal all over the tank and melts it again for use in wiping the bull's eyes. Fig. 23 shows how this is done. A newspaper is pasted to the lining below the bull's eye to catch any falling solder. The plumber splashes the solder into the cavity with a splash stick. When the bull's eyes are thoroughly tinned, they are wiped flush with the face of the lining, and the screw heads are thus protected from the water. This finishes the wiping of the tank, which is now swept clean: the lining is then beaten back with the lead flap previously used until it is against the woodwork.

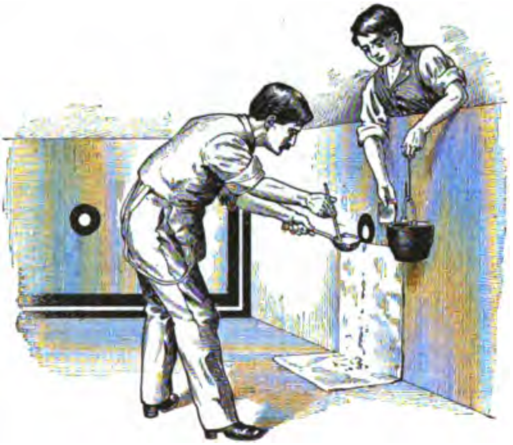

FIG. 23

20. The **corner pieces** on top of the tank are now put in; they are soldered on with the copper bit, and the tank is ready for its braces, which are put in place and carefully bolted up tight; the tank is then ready for its connections.

21. Fig. 24 shows an inside corner of a lead-lined tank in which the base of the upright corner seam joins two horizontal corner seams. In wiping such a tank, it is customary to begin at the top of the vertical seam and work down to its bottom, as previously mentioned, and then to wipe along toward the right hand about 6 inches or 1 foot, as shown at *a*. Wiping is then commenced at *b* and continued toward the left until the seam is wiped all around the bottom, finishing at *a*.

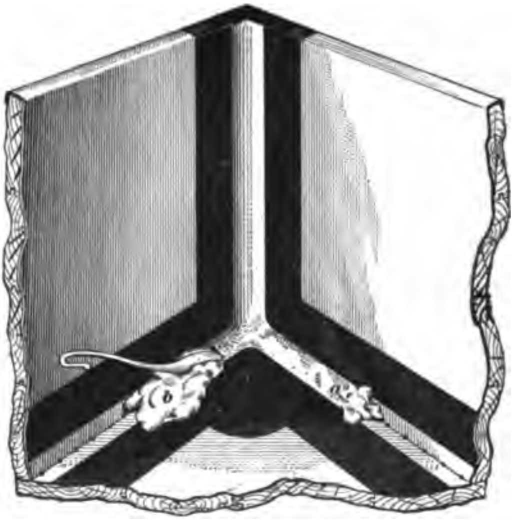

FIG. 24

LINING TANKS WITH COPPER

22. While it seems somewhat illogical to consider the lining of tanks with sheet copper under the heading of Lead Work, nevertheless, the similarity of the work to that done in lead lining warrants it being considered here in order to avoid repetition.

In lining house tanks with sheet copper, the seams that can be made in a horizontal position are usually soldered with a bit, but all upright seams that must be made in position should be wiped in a manner similar to that already described, with this difference, that no soil is used. If a tank iron is used to maintain the heat of the seams while wiping them, a strip of paper should be pasted on the copper for the same purpose that soil is used on lead. If a gasoline torch is used to raise the heat of the seam, the tinned surface of the copper is left uncovered.

23. The seams of copper linings should always be **locked,** or **double seamed,** in such a manner that the tinned surface of the copper will come together in the lock. If the copper sheets are not tinned, the edges must first be tinned to a suitable width with the copper bit, using chloride of zinc as the flux. The upright seams are secured to the tank with tinned nails to prevent their bulging while being wiped.

The application of the solder to the seams and the wiping of them are the same as for those in lead-lined tanks, except that the solder must be worked ahead, as otherwise it will adhere to the tinned surface of the copper sheets. If a tank that is lined with tinned copper is properly wiped, the seams will be smooth and almost invisible.

24. The thickness of tank linings should vary with the depth of the water. For a tank about 4 feet deep, 16 or 20 ounce copper or 6 or 7 pound sheet lead is considered the proper weight. If the tank is deeper, heavier material should be chosen. The size of the parts into which the lining is divided is governed by their weight and the facilities at hand for lifting and handling them, etc. In the case of large surfaces, bull's eyes, or **solder dots,** as they are often called, should be located from 2 to 3 feet apart for lead linings and from 3 to 4 feet apart for copper linings.

25. In laying out the copper lining, it is advisable, if possible, to arrange the sheets so that no wiped seams are necessary. This can always be accomplished in tanks that can be turned over on their sides. Other tanks will have at least one upright seam that should be wiped instead of soldered. All copper-bit seams should be on horizontal surfaces, as on the bottom in large tanks, and away from angles, as shown at *a*, *b*, and *c*, Fig. 25, and they must all be locked seams to give satisfaction. In making the seam *b*, Fig. 25, the sheet should be cut as shown in Fig. 26. The dotted lines show where the sheet should be bent. The miter cut at *a* when closed and locked forms the miter seam *b* in Fig. 25.

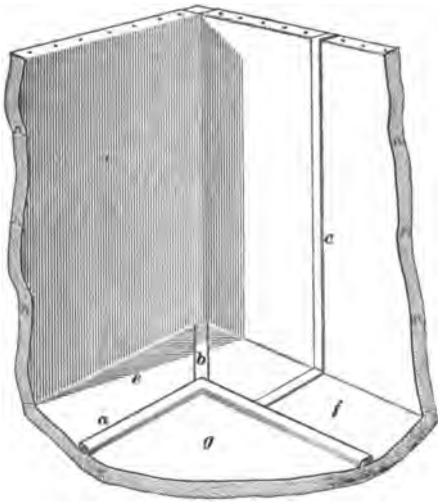

FIG. 25

26. In lining tanks with copper, the sides and ends are lined first, the base of these sheets being lapped over on the bottom of the tank, as shown at *e* and *f* in Fig. 25. After the sides are finished, the bottom piece *g* is laid in place and locked all around, as at *a*. All the seams are then thoroughly flattened with a mallet and soldered.

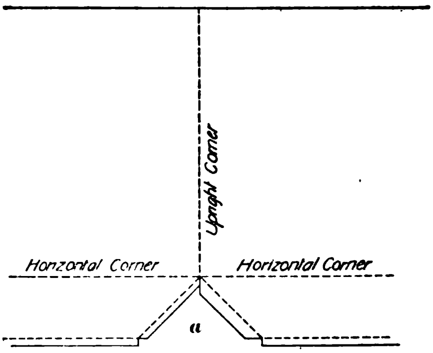

FIG. 26

BLOCK-TIN LINING

27. Block tin is seldom used by plumbers except for making solder or in the form of pipes. The pipes are bent and otherwise worked in a manner similar to lead pipes. For covering the top boards of pantry sinks, etc., sheet tin rolled from pure block tin is preferable to lead, zinc, or copper. It tarnishes very slowly, is easily kept clean, is durable, and easily receives a high polish that makes it resemble silver.

28. In Fig. 27 is shown the manner of cutting the block-tin sheet to cover the wooden top of a pantry sink, which is shown by the dotted lines. The sheet is cut at *a* and *b* larger than the top, and at *c* and *d* smaller than the hole in the top, so that it may be bent around the edges and nailed underneath, as shown in the section at the right. Sufficient metal is left on at *e* and *f* to form upstands or splash plates, *e* being of such a shape that when the plates are turned up, the part *g* can be bent around *f* to form a lap joint in the corner. This joint is then neatly soldered with the blowpipe.

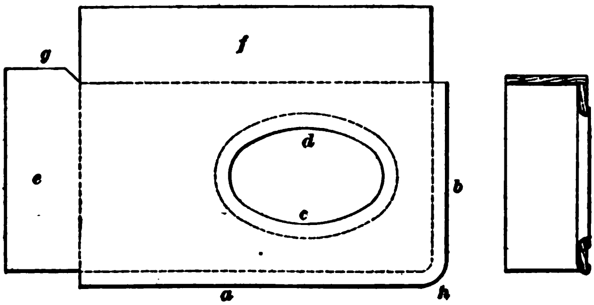

FIG. 27

The sectional view shows the top covered and *e* and *f* bent up in position. The tin can be bent neatly over the outside corner *h* by smoothing it down with a hot flatiron. The margin of tin allowed at *c* and *d* can be worked down and under the cover by means of a warm, smooth round bar *a* in Fig. 28, which shows the manner of applying it.

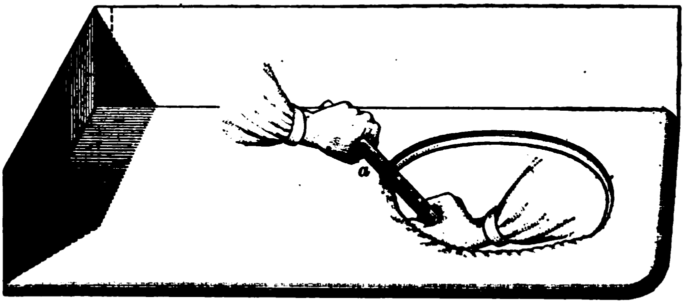

FIG. 28

DETAILS OF SHEET-LEAD WORK

MAKING UPSTANDS

29. Angles, or **upstands,** in sheet lead may, if the sheet is small, be bent over the edge of a plank, as shown in Fig. 29, the dresser being used to flatten the lead against the plank and thus make a neat corner. It should not be bent over a sharp iron edge, because this edge will cut into

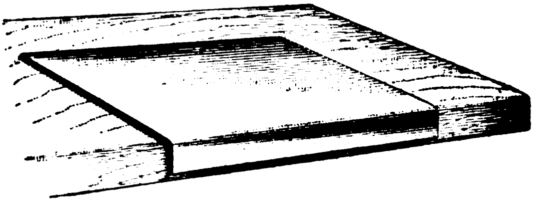

FIG. 29

the lead and weaken it at the corner, as shown at *a*, Fig. 30. Sheet lead should always be bent over a rounded edge, and the dresser should not be applied to the edge, but only to the flat surfaces. This will leave the edge as strong as the sheet; the edge will have the appearance shown at *b*.

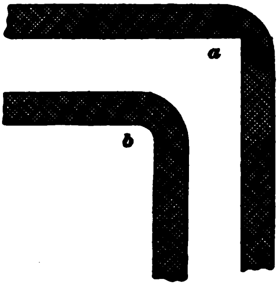

FIG. 30

Care must be taken to bend up the sheet so that it will be a tight fit when put in place. Inexperienced sheet-lead workers usually put the lead in too small and then drive the corners back, which stretches the lead at the corners and often tears it. A good plumber never stretches sheet lead. He rather works to thicken it.

FORMING CORNERS

30. Pig-Earing Corners.—A simple method of forming the corner in an upstand, as occurs for instance in

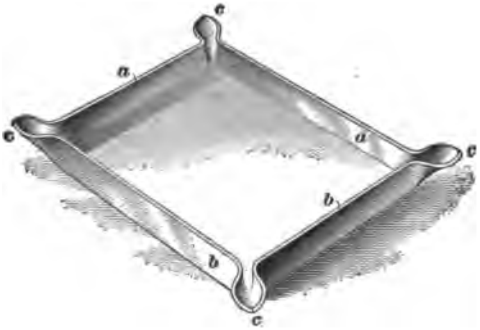

FIG. 31

safes on cheap jobs, is known to the trade as **pig-earing corners.** The upstands are bent up, as at *a* and *b*, Fig. 31, folding the corners *c*, *c* into a shape like a pig's ear. This ear is then flattened and bent around, as shown in Fig. 32, to form a water-tight corner. On the better class of work, however, these corners are *worked up* and the surplus metal is cut off instead of being bent around.

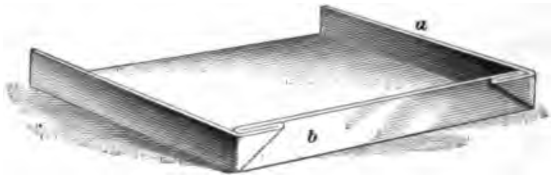

Fig. 32

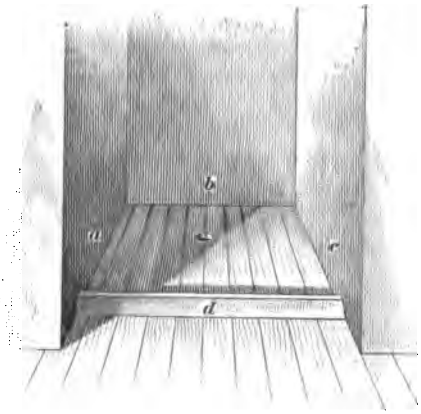

Fig. 33

31. Working Corners.—The working of corners requires more skill than pig earing, but it is better and neater and indicates the work of a skilled mechanic. Suppose a safe is to be laid on the floor of the recess shown in Fig. 33. The lead is cut to the proper size, allowing 3 inches for upstands around the sides *a*, *b*, and *c*, and also for the front, which permits the lead to be folded 1 inch over the top of the strip of wood *d* that is 2 inches high. All four upstands are bent up, pig earing each corner, as shown in Fig. 34. Then the bottom near each corner is bulged up with the mallet to stiffen the sheet. The pig ear is made up of easy curves. A block of wood or the head of a mallet is held into the corner and the surplus metal in the pig ear is gradually beaten up with the handle of the dresser, striking the blows in the direction of the arrows shown in Fig. 34. The mallet is used to keep out kinks, and the dresser handle to knock the surplus metal up into the ear *a*, which when high enough is cut off with a knife and finally dressed to the form of a seamless square corner, as shown at *b*. The ear that was cut off *b* is shown at *c*. If the corner is properly worked, it will not be much thinner than any other part of

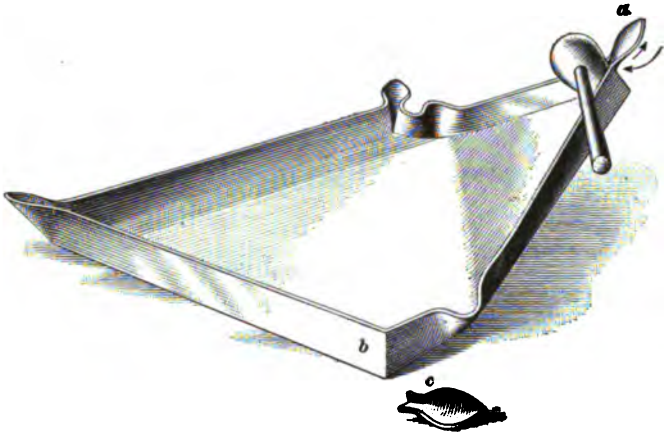

FIG. 34

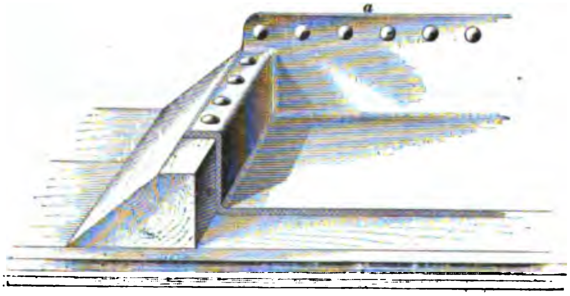

FIG. 35

the sheet. If the fillet, or strip, *d*, Fig. 33, is beveled inside, the front corners can be worked in place. If it is square inside, the corners should be worked up 2 inches and then finished and trimmed in place. Fig. 35 shows a neat method of finishing at the end of the fillet. There is no joint or seam, the lead being neatly worked into the corners. The edges of the safe are nailed all around to the wall with brass or copper flat- or round-head tacks, as shown. The corners shown in Fig. 34 are called **outside corners,** and are more common than inside corners.

32. A good way to work up an **inside corner** is to first cut the lead so that a surplus will be allowed at *a*, Fig. 36, sufficient to compensate for the stretching that naturally occurs. In Fig. 36, *b* is the body of the sheet and the parts *c*, *c*, *c* are to be bent up at the dotted lines. The inside corner is located at *d*. The upstands are bent up as close to the corner as they will go by hand. The sheet is then bulged up at *e* and *f*, to stiffen it. A mallet is now used to drive the surplus uniformly into the corner, so as to thicken rather than thin the metal. It must be worked in easily, uniformly, and steadily, without distorting the general form of the sheet, and great care must be taken to avoid tearing the lead. If the outside corner is close to the inside corner, as shown in Fig. 36, some of its surplus metal can be worked toward the inside corner.

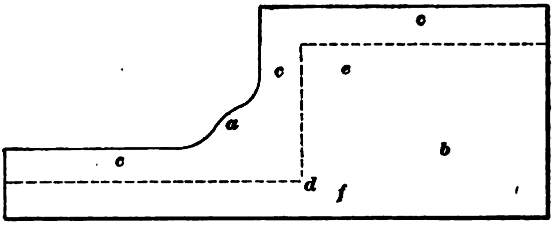

FIG. 36

LEAD-PIPE WORK

HANDLING LEAD PIPE

STRAIGHTENING LEAD PIPE

33. The **straightening of lead pipe** is usually accomplished by stretching, rolling, or by drift plugs. If the pipe is long and of small diameter, it can be stretched out straight like a rope. If, however, it is short and of considerable thickness, as water pipe, for instance, it can be straightened by rolling on a flat surface and by driving down the irregularities with a block of soft wood and a hammer. Thin waste pipes, however, if badly bruised and flattened, must be first straightened in a general way and then a drift plug should be driven through to push out the kinks and give the pipe an equal and full bore throughout its length. Fig. 37 shows how the kinks at *a* are removed. A small drift plug *b*, well greased, and followed by a drift plug *c*, which fits the full bore of the pipe snugly, is forced through the pipe by repeated blows from a wooden rod or piece of iron pipe *d*. Occasionally, it is necessary to help the plugs through by beating or dressing the kinks around the plugs, and thus easing them.

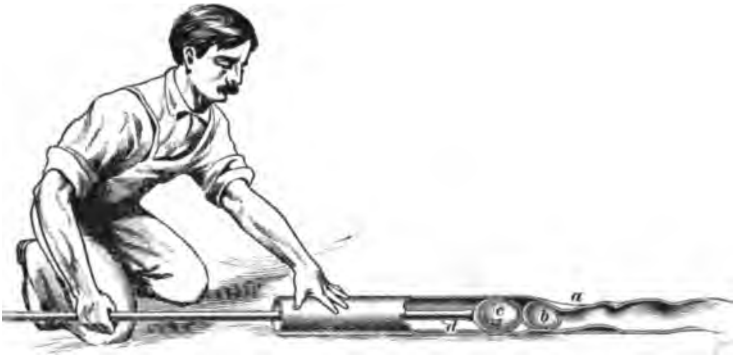

FIG. 37

CUTTING AND CARRYING LEAD PIPE

34. Small sizes of lead pipe, called **tubing,** are cut with a pocket knife; larger sizes are cut with a saw. In cutting pieces off a coil, care should be taken to leave the end straight for a few inches. While cutting lead waste pipe, it is necessary to be careful not to kink it.

35. Coils are usually rolled from place to place, but when it is necessary to carry one, the weight should be taken on the shoulder and the back should be kept straight, otherwise the back may be strained. The proper way to carry a length of waste pipe is to spread out the arms so that the hands will be about as far apart as half the length of the pipe; the person should be in the center of the length.

BENDING LEAD PIPES

PLAIN BENDING

36. Fig. 38 shows how water pipes are bent by hand.

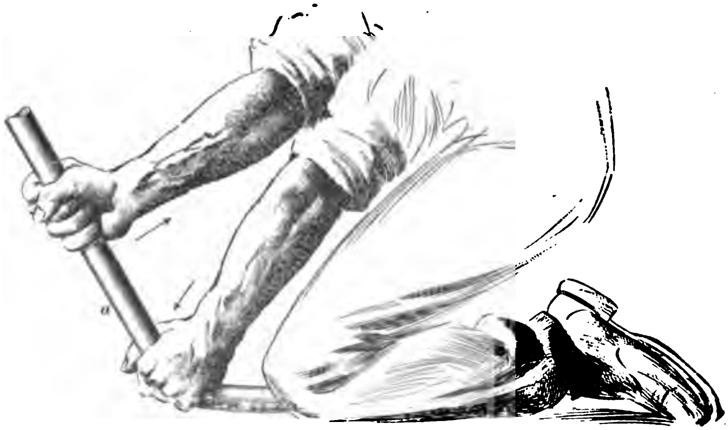

FIG. 38

The left hand pushes down on the place where the pipe should be bent, and the right hand pulls up the pipe and forms the bend, as shown. If the pipe *a* is too short, a bending pin is pushed in the end and used as a lever for pulling it up. It is not necessary to fill the bore of water pipes before bending, because the lead is thick enough to prevent the pipe from flattening at the bend.

37. Lead pipe of the grades A A A, A A, A, or B is frequently bent over the knee or over a rounded block without materially distorting the circular section of the pipe unless the bend is a very sharp one, in which case care must be taken to prevent the pipe from kinking or flattening sidewise.

SAND BENDING

38. Large pipes and those made of thin material may be bent and kinking avoided by filling them with dry sand and thoroughly ramming it. There is an objection to bending pipes in this manner, however, in that metal forming the outer curve, or **heel,** of the bend is stretched and made thinner, while that forming the inner part, or **hass,** *a* is compressed and thickened, as shown in Fig. 39. The gain of metal in the hass is slight compared with the loss of metal at the heel. The heel, consequently, is the weakest part of the pipe. To avoid this, the bend should have as easy a curve as possible. Lead waste pipes having a diameter greater than 2 inches should not be bent with sand unless the bends are very easy.

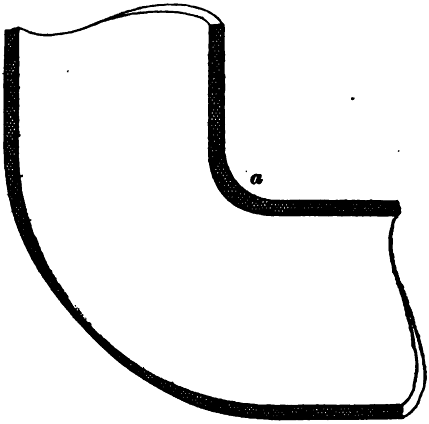

FIG. 39

39. Fig. 40 shows an offset made on a piece of 2-inch lead waste pipe. The bend *a* shows that the sand has not been properly packed and that it has yielded and been displaced. At *b* is shown a bend in a well-packed pipe. The heel of *b* will be much thinner than that of *a*.

The wooden sand plugs *c*, *c* are driven into the ends of the pipe, not only to keep in the dry sand, but also to give more leverage in bending the pipe; the bend can also be made nearer the end, which is often desired. By heating the sand immediately before pouring it into the pipe, the bends can be made more easily.

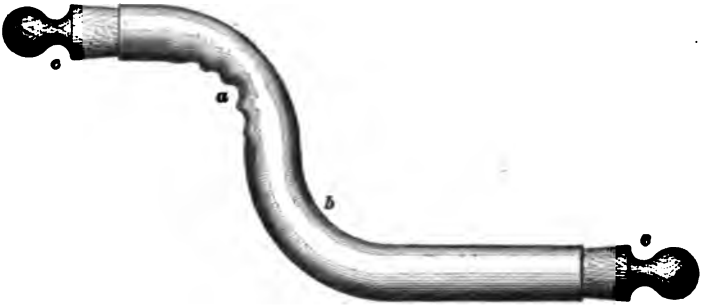

FIG. 40

BENDING WITH A COILED SPRING

40. Sometimes a close-coiled steel spring is used for bending. This is well greased and placed inside the pipe where the bend is required; the pipe is then bent over the knee like a water pipe. This, however, makes a very thin heel and is no better than sand bending. It is often used, however, for 1¼, 1½, and 2 inch waste pipe. To remove the spring after the pipe is bent, simply unscrew it, i. e., twist it to the left, if the spring is coiled right-handed, which makes it smaller in diameter. By pulling and twisting, it will come out.

BENDING WITH BOBBINS

41. A much used method of taking out the kinks in lead waste pipes is by means of wooden balls called **bobbins.** Fig. 41 shows the manner of doing this. After the pipe has been bent in the usual way (over the knee or block) different sizes of bobbins are inserted, after having been well greased, beginning with the smallest one and following it up in regular order with the larger ones, as shown in the illustration. After the bobbin *a*, whose diameter is the same as that of the pipe, has been inserted, a number of bobbins *b*, *b*, called the **followers,** are inserted. These are of smaller diameter than the pipe, so that when the largest bobbin *a* is driven through and out of the pipe by ramming the bobbin with a rod *c*, the followers will drop out easily.

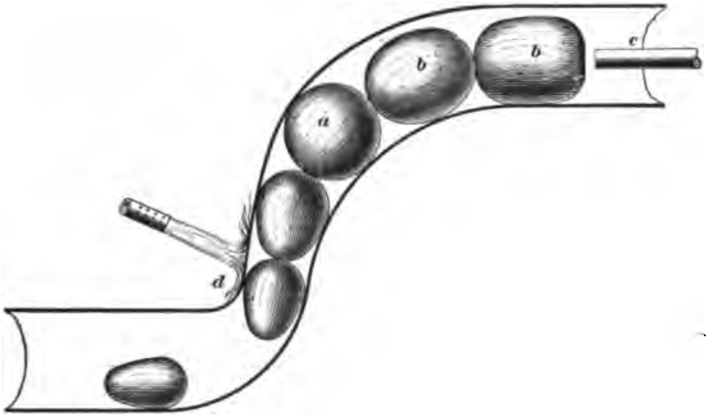

FIG. 41

If heat be applied at the throat, as at *d*, it will soften the lead at this point and thereby cause it to yield more easily to the outward pressure of the bobbins and cause less thinning of the heel, particularly if the heel be kept cool with a wet cloth. The superfluous lead on the sides can be dressed back to the heel. This will somewhat make up for the loss in thickness of this part, which is caused by the pressure of the bobbins as they are driven around the curve.

BOSSING OUT BENDS

42. A process of driving out the kinks formed in the hass during the bending of lead pipe, using a bent rod, or a dummy, is known as **bossing out.** Fig. 42 shows how the kinks are driven out. The **dummy** *a*, which is simply a piece of cane about 10 inches long and supplied with a lead

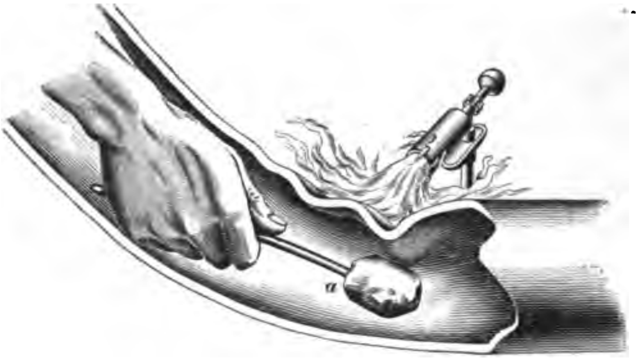

FIG. 42

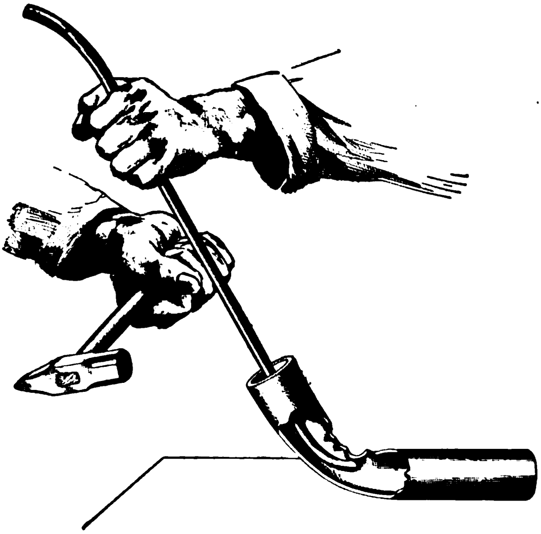

FIG. 43

head, is applied to the kinks, which are heated from the outside with a gasoline torch to soften the lead; the kinks are then easily driven out. Care must, of course, be taken not to melt the lead.

43. If the pipe is too small to work the hand freely, a long bending pin, made out of ½ or ¾ inch pipe, is used, as shown in Fig. 43. The point should be rounded off with a file. The kinks can then be driven out by hammering on the pin, as shown.

44. If the bend is quite far from the end, say 18 inches or more, it is advisable to use a long dummy and a fulcrum, as shown in Fig. 44. A sudden jerk downwards on the end *a* will throw up the loaded end *b* with great velocity and will drive the kink *c* in the pipe outwards.

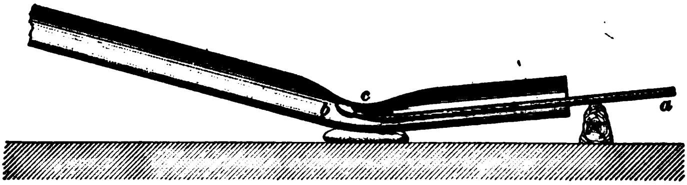

FIG. 44

45. In all these methods of driving out the hass, the operations of bending up and bossing out are applied alternately until the bend is worked up to the desired angle. In bending the pipe, the sides bulge out a little, as shown in Fig. 45; these bulges should be driven in with the dresser in such a manner that the

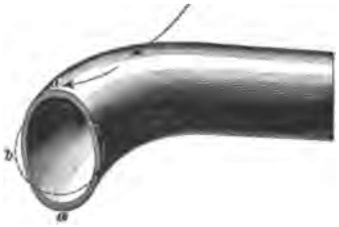

FIG. 45

surplus metal at *a* will be worked over to the heel *b* of the bend. The arrows show the direction of the blows of the dresser. A good mechanic can thus make the heel the thickest part of the bend.

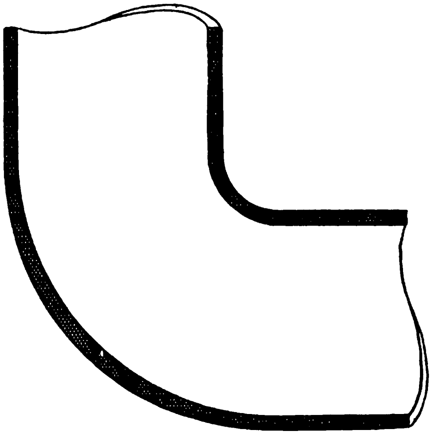

FIG. 46

46. Fig. 46 shows a well-made lead bend, in which the heel is thickest. It is found to be superior in every respect to a sand-made bend, but it is also more costly.

LEAD BURNING

APPARATUS

THE PROCESS

47. The process called **burning** is used for joining the edges of lead sheets or pipes without solder. The edges are fused to an extent that permits the parts to unite and form one solid piece when cooled. This process is known as the **autogenous process,** and although it has been practiced for centuries, it is used far less at the present day than it should be. It affords a quick and cheap method of making lead joints of the most durable character, and it may be used with profit in many cases instead of the soldering process now commonly employed.

Solder cannot be used for joints that are exposed to contact with acids, because most of the ordinary acids will dissolve the tin, of which the solder is in part composed.

Tanks that are used for the manufacture or storage of acids, or acid salts, or for the storage of mineral oils, petroleum, etc., are usually lined with lead. The joints in these linings and in all of the lead pipes that are used for the same purpose, must be made by burning.

The operation is performed by melting the edges to be joined, a drop at a time, by means of a blowpipe. It is essential that the flame used shall not oxidize or tarnish the metal. If the drop of melted metal does oxidize, it will not unite with the solid parts, and the joint will be a failure.

The most certain and convenient way to secure a non-oxidizing flame is to use hydrogen gas mixed with air to supply the blowpipe. Other methods may be employed, but none are so convenient as the hydrogen-gas process.

THE GENERATOR

48. The apparatus required for lead burning consists of a *gas generator*, an *air pump* and *storage tank*, or *holder*, and a *compound blowpipe*. The internal construction of a generator and gas holder is shown in Fig. 47. The **gas generator** consists of an open chamber *a*, which is lined with lead, and a lower chamber *b*, also lined with lead, which is made air, or gas, tight. A perforated pan, or tray, *c* is suspended 1 inch or more above the bottom. The upper and lower chambers are connected by a lead pipe *d* that extends below the pan *c*, as shown. The chambers are protected by a stout wooden casing against injury or accidents; the casing also serves to retain the heat that is generated in *b* while making gas. The gas passes upwards through the bent pipe, which dips about ½ inch below the water that is contained in the chamber *e*. Thus the gas is compelled to bubble upwards through the water before it passes out of the cock *f* to the

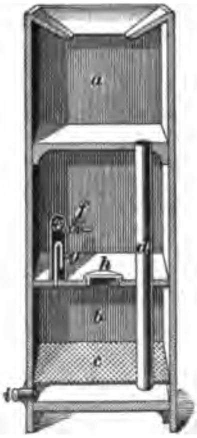

FIG. 47

blowpipe. This arrangement constitutes a fire-trap that will prevent an explosion in the hose from firing the gas in the machine. In order to regulate the height of the water in *e*, a small petcock, or plug, *g* is provided.

49. To make gas, a quantity of commercial zinc in lumps from 1 to 2 inches long is placed in the copper pan *c*. The plug *h* is then screwed into place and made gas-tight, and the gas-cock *f* is opened. Having previously ascertained by experiment the quantity of water that will exactly fill the chamber *b*, a mixture of 5 parts of water and 1 part, by volume, of commercial sulphuric acid is prepared. A quantity of this mixture that will just fill the chamber *b* is then poured into the upper chamber *a* and allowed to flow into *b*. The generation of gas will begin as soon as the acid mixture encounters the lumps of zinc in the pan *c*, but as the cock *f* is open, the liquid will all flow into and entirely fill *b*, thus forcing the air in *b* to the atmosphere.

When *b* has been entirely filled, that is, when all the liquid poured into *a* has flowed into *b*, and gas and liquid spurt out of the cock *f*, the cock is closed, and the rubber tubing that is to conduct the gas to the blowpipe is then attached to *f*. The gas generated in *b* will now rise to the surface, and by accumulating there will force the liquid up the tube *d* and into *a*. The pressure of the gas will increase with the height of the liquid column in *d* and *a*. As soon as the liquid in *b* is forced below the perforated pan, the formation of gas will cease, and, of course, at this point the maximum pressure of the gas will be obtained. The machine will then be ready for use.

The object of blowing the air out of *b* before allowing gas to accumulate is to prevent a mixture of air and gas, which is explosive, and which, if ignited, may blow the machine to pieces and injure or probably kill the workman.

50. The machine should not be allowed to stand over night with a charge of liquid in it, because it will clog up with a deposit of sulphate of zinc. As soon as the workman is finished for the day, the drain plug *i* should be removed and the apparatus emptied of liquid. Two pails of clean water should be run through it to remove the deposits and cleanse it.

The utmost care must be taken to keep the chamber *b* perfectly air-tight. Its tightness should be frequently tested by shutting the cock *f* and filling the upper chamber with clean water, allowing it to stand for at least 1 hour and taking note of the exact height of the water. If the water sinks during the test, a leak is surely indicated, and if a leak exists, the machine must be examined until the leak is found and repaired. A very slight leak may cause a disastrous explosion.

The zinc that is used for making gas should be of the ordinary commercial quality. Pure zinc works very slowly and is not satisfactory. About 3 ounces of zinc will furnish 1 cubic foot of gas. The charge of zinc should be about 20 to 25 pounds for a machine that is intended to run all day.

51. A generator of convenient size is about 10 inches square and 33 to 36 inches high. A larger machine would be advisable for heavy work. If the amount of liquid contained in a generator is small in proportion to the amount of zinc, it will soon become saturated with the sulphate of zinc that is formed during the process of making gas, and the evolution of the gas will cease. Considerable heat is liberated while the gas is forming, and the generator works best while hot. As soon as the temperature falls, the sulphate will begin to crystallize and will form a coating all over the pieces of zinc; it may clog up the holes in the pan *c*, or it may even choke up the inner end of the delivery pipe *d*.

This clogging may occur while the workman is away at dinner. If the liquid is not nearly saturated with sulphate, or **spent**, as it is called, it should be driven back into the upper chamber by attaching the air pump to *f* and pumping air into *b*; by inserting a wooden plug in the top of *d*, the liquid can be held in *a* as long as desired. Then the zinc can be taken out and washed clean with hot water. Care must be taken to force the air out of the machine, as previously directed, before resuming work.

Explosions of hydrogen gas mixed with air are very violent, and care must be taken at all times to keep away all lights or fires from the vicinity of the generator while opening it or while blowing out any gas. This danger is probably the chief drawback to the use of the machine, but in the hands of careful workmen no trouble is likely to happen.

THE AIR SUPPLY

52. The air supply necessary to operate the blowpipe may be furnished by a bellows or a blower, or almost any kind of a pump, but to operate the blowpipe to the best advantage, the air blast should be perfectly steady and smooth. A good way to obtain a proper blast is to use the **air holder** shown in Fig. 48. This consists of a hollow cylinder *a* of galvanized iron, open at the lower end, which is immersed in a tank of water. The outer tank *b* should be about 1 inch larger in diameter than *a*. The cylinder *a* should be confined by suitable guides, so that it cannot tip sidewise and bind. The air cocks may be attached to the top of *a*. The pressure of the blast may be regulated by placing more or less weight on the top of the floating cylinder. One of the air cocks should be connected by rubber tubing to the blowpipe and the other to the air pump. In practice the pump is operated until *a* rises to its highest limit, and the cock is then shut off until *a* has sunk nearly to the bottom of its range, when pumping is repeated. Continuous pumping is not required. Care must be taken that the pressure of the air is not greater than that of the gas from the generator; otherwise, the air may work back through the gas tube into the generator and cause an explosion of the apparatus.

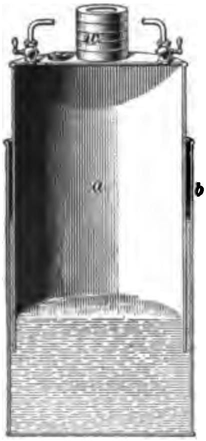

FIG. 48

MANIPULATION OF THE APPARATUS

53. Fig. 49 shows the general arrangement of the apparatus. The gas from the generator and the air from the holder are not mixed until they reach the mixing pipe *a*. The proportions of air and gas are determined by adjusting the cocks to which the rubber tubes are attached, and the force of the jet is also adjusted in the same way. This mixing pipe should be as closely behind the blowpipe as convenience will permit. The mixture of air and gas is very explosive, and the fire may flash back from the jet to the mixing pipe, spoiling the tubing, if nothing worse. In some forms of blowpipe the mixing cocks are attached to the blowpipe. The blowpipe should be provided with several sizes of jets, or nozzles. A jet of $\frac{1}{32}$-inch bore is of proper size for working on 4-pound lead. The diameter of the bore of the nozzles used for heavier lead will increase slightly with the thickness of the sheet. About $\frac{3}{32}$-inch bore will be required for 12 to 20 pound lead.

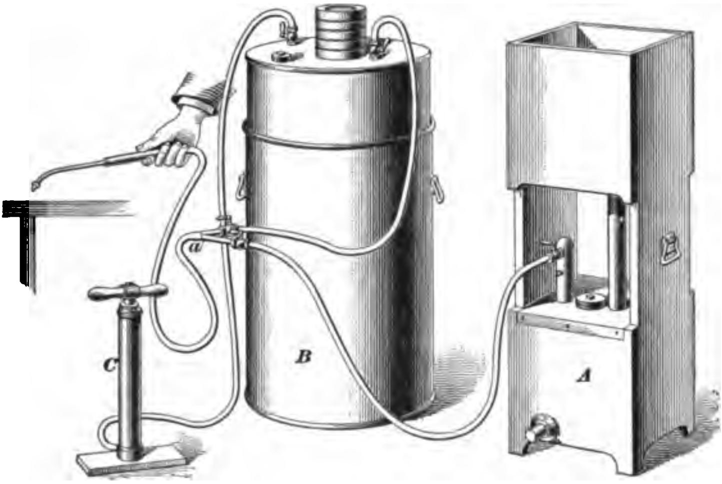

FIG. 49

The rubber tubing that connects the blowpipe to the gas generator and the air holder should be of $\frac{1}{4}$ to $\frac{3}{8}$ inch bore, and of extra heavy rubber, so that it will not kink. It should be connected by means of screw couplings. If the tubes are merely slipped over nipples and are not wired, they are liable to be pulled off while working.

Vapor is liable to condense in the tubes; clots of water are liable to be blown into the blowpipe and extinguish the flame. In that event, the tubes should be disconnected and hung up to drain until they are dry. The tubes should be detached from the generator and the air holder at the end of each day's work, and be hung up to drain and dry out.

The cock on the generator should be kept closed while the blowpipe is not in use, but should be opened wide when ready to proceed with work. The regulation of the gas flow should be done by the gas-cock on the mixing pipe.

To start the blowpipe, the air cock is first shut; then the gas-cock is partly opened, and as soon as gas flows from the jet it is ignited. The flame at first will be long, noisy, and unsteady, with very little color. The gas-cock is then gradually closed until the flame is reduced to about 3 inches in length. The air cock is then slightly opened and air is admitted to the flame. The supply of air is gradually increased until the flame is shortened to about 1½ inches, or until the flame is sharp-pointed, compact, rapidly darting, noiseless, and divided into two well-defined flames, one inside of the other. The inner flame should be very distinct, and its apex, which is the point of greatest heat, should be blue. The outer flame is of a pale reddish color, and its temperature is much lower than that of the inner flame. The two flames differ greatly in their effect on metals. The outer flame will oxidize the metal that it touches, but the inner flame will melt the metal and keep it hot as long as desired without oxidizing it. Consequently, the inner flame is used exclusively in the operation of lead burning, and the contact of the outer flame with the metal is avoided as much as possible.

54. Fig. 50 exhibits the various forms of the flame as the proportions of air and gas are changed. The clear gas makes a flame as shown at the extreme left. As air is introduced in increasing quantities, the flame takes, in succession, the shapes shown toward the right, until it reaches the correct working shape shown in the third view from the right. The second view from the right shows the effect of too much air, and the view on the extreme right shows the flame on the point of going out from excess of air or lack of gas.

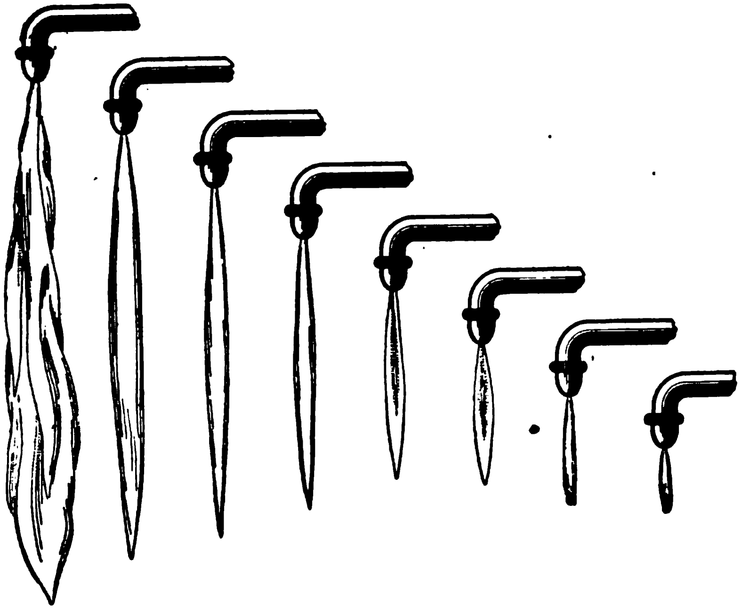

FIG. 50

It should always be borne in mind that the gas must be turned on and ignited before air is admitted, and when it is desired to extinguish the flame, the air must be shut off before the gas-cock is touched. To increase the flame, increase the gas first, then increase the air; to diminish the flame, check the air first, then reduce the supply of gas.

BURNING JOINTS AND SEAMS

55. To learn the characteristics of the flame, and how to handle it, a person should practice on a piece of sheet lead that has been cleaned with the shave hook. Quickly bring down on the clean lead the point of the inner flame. Almost instantly a disk of melted lead will be formed; then quickly remove the flame. The melted metal will cool bright, showing that it has not been oxidized. Now bring the end of the outer flame to bear on the clean lead, keeping the inner flame about $\frac{1}{8}$ or $\frac{1}{4}$ inch away. The lead will quickly tarnish, and although it will melt, it will be covered with a coat of gray oxide.

Again bring the point of the inner flame to bear on the clean lead, melt a little, and then withdraw the flame slowly, allowing the outer flame to act on the molten part; a film of gray oxide will spread over the molten metal, and it is then spoiled for joining purposes.

It will also be found that unless the flame is withdrawn with proper quickness, ugly holes will be made in the sheet metal.

Further experiment will disclose the fact that if a **bead,** or drop of lead, is maintained in a state of fusion, and if a small part of the leaden sheet on or against which the lead rests is also fused, the lead will quickly flow to and unite with the molten part of the sheet, and will upon cooling form a perfectly homogeneous mass with it. The union will be perfect, provided that all oxidation is avoided. This is the essential part of the process of lead burning. The attraction of the two portions of melted lead for each other is so strong that the effect of gravitation upon the bead is apparently diminished to a considerable extent, and it is found that the bead can be made to travel in almost any direction. The size of the bead must be varied to suit the thickness of the metal that is to be joined, and also to suit the direction of the joint, whether horizontal or vertical, inclined or inverted.

The strength of a joint made by burning depends a good deal on the size of the bead made by the blowpipe flame;

therefore, it is important that the bead should not be made too small. If the bead is too large, the joint will present a very uneven surface, as the weight of the bead will overcome the attraction of the melted metal near it, so that it will fall away from the desired place and be unmanageable. Care must be taken to avoid fusing too large a spot in the sheet at any one time, because the sheet will be thinned out and weakened by it.

Fig. 51 shows two sections of lapped joints, of which the left-hand one is properly made, while the right-hand one has been badly weakened by too much fusion.

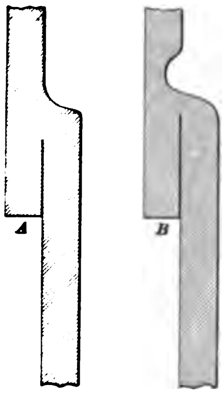

FIG. 51

56. A person is advised to begin practice on a **butt seam** on the bench. He should first prepare two pieces of sheet lead by planing the edges to be joined straight and square, and shaving the top surfaces clean about $\frac{1}{4}$ inch wide on each side of the butt joint; then butt the edges together and secure the sheets firmly to a board. The extra lead that is necessary to make a butt joint, that is, to supply the beads, must be obtained from a lead stick. This should be $\frac{1}{8}$ inch or more thick, triangular in section, and shaved clean.

The blowpipe flame being regulated to the proper shape and size, the burning is begun at the nearest end of the joint, as *a* in Fig. 52. With the point of the inner flame melt off a drop of lead from the end of the lead stick and allow it to fall squarely on the seam. Follow it up instantly with the flame, placing the point of the inner flame exactly over the edges of the seam, which are under the bead. They will quickly melt and unite with the bead. The flame must be withdrawn before the fusion proceeds any farther than necessary to secure that one bead in place. If the operation is properly performed, a section through the bead will appear as at *b* in Fig. 52. Now proceed to drop another bead on the seam, but lapping about one-third of its diameter on the previous bead, and secure it to the seam in the same way. Each successive bead fuses into and unites with the preceding one and with the edges of the sheets, thus forming a continuous joint. A person will soon learn to make the beads follow one another in rapid succession.

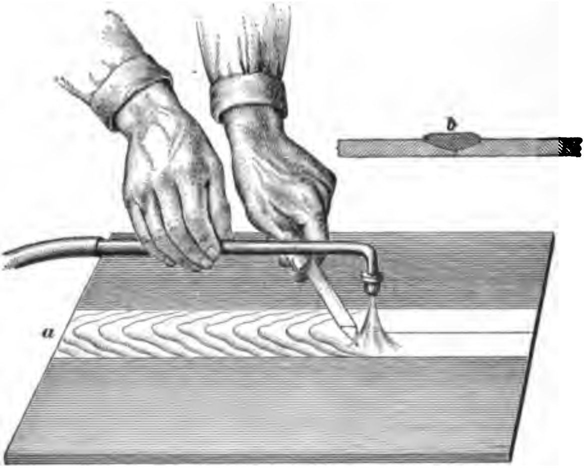

FIG. 52

The movements of the blowpipe in melting off the bead, dropping it on the seam, fusing the edges of the seam, and backing off from it are repeated in quick succession, the hand of the operator moving in a circular path and gradually advancing from him as the joint progresses.

Making this form of joint should be practiced until perfect control of the flame is secured and the operator learns how to handle the blowpipe so as to secure the beads in their proper place uniformly and rapidly.

57. The next thing to be learned is how to make a **flat lapped joint,** as shown in Fig. 53. The sheets should be planed, squared, and shaved where they touch each other, and the upper surfaces should be shaved clean about $\frac{1}{4}$ inch each side of the edge of the upper sheet, as shown. They should lap about ½ inch for 6-pound lead.

In lapped joints no lead stick is required, the beads being melted off the edges of the upper sheet. Beginning at *a*, the flame is first brought to bear on the upper edge *b* of the top sheet, and a bead is melted off. The flame is then quickly moved backwards and downwards so that it will bear on the lower sheet. The bead will follow the flame, and as soon as the lower sheet begins to fuse, the bead will promptly unite with it. The flame must be instantly lifted away and returned to the edge of the sheet for the next bead. Each successive bead is similarly secured a little in advance of, but lapping on, the preceding one. In performing the successive movements required to fix each bead, the hand of the operator travels continually in small circles, and slowly advances as the joint progresses.

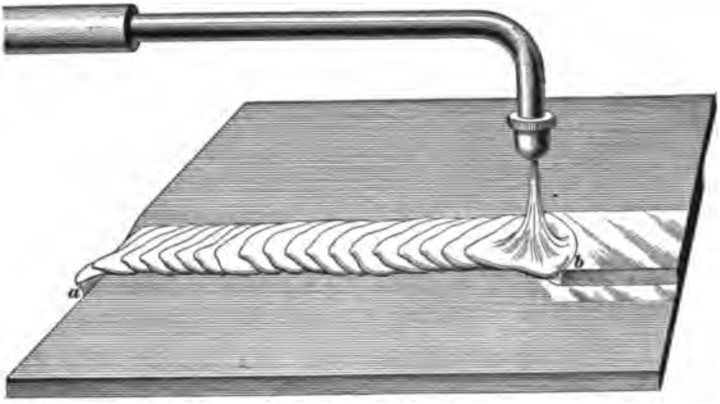

FIG. 53

A skilful operator will fix each bead firmly and evenly in place, and never deviate from the proper line of the seam.

58. The **horizontal lap joint** in vertical sheets is shown in Fig. 54. The bead is melted from the top edge *a* of the sheet, is driven by the flame against the back sheet, and is held there until the sheet begins to brighten; at the instant that fusion begins, the flame is lifted away. The bead instantly takes hold of the back sheet, and if properly managed, forms a joint like that shown in section at the left hand of Fig. 51.

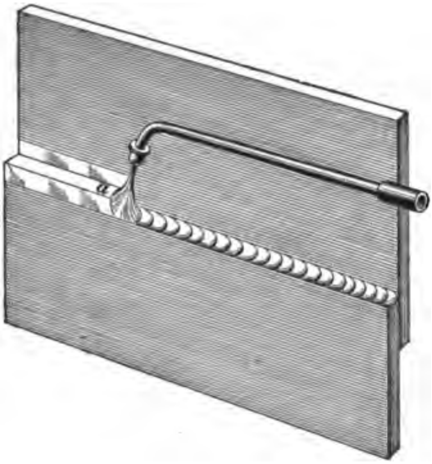

FIG. 54

59. The **vertical lap joint** is shown in Fig. 55. The joint is begun at the bottom of the seam, and is gradually worked upwards. The bead of lead is melted off at *a*, and is flowed downwards to *b*, where it is united to the back sheet as in previous operations. However, the bead does not flatten out so much as in horizontal seams, but cools in the form of a split pea.

In making vertical and inclined joints, the size of the bead becomes a matter of great importance. The operator is advised to make vertical seams for practice, noting the size of the bead employed; and then to cut squarely across the joints so made, and ascertain the extent and apparent strength of the joints. No reliable knowledge on that point can be obtained in any other way.

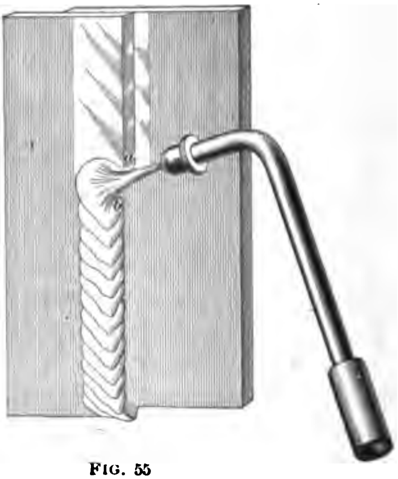

FIG. 55

The knowledge gained by experimenting with vertical joints will enable a person to make inverted joints, that is, joints having the lap on the under side. These joints cannot always be avoided, and while they require a little more patience and skill than the ordinary horizontal joints, the art of making them can be readily acquired.

60. The mode of burning **joints in vertical pipes** is shown in Fig. 56. The end of the lower section is first cupped as for an ordinary solder joint, and is then dressed into a socket, as shown, and is shaved on the inside, on the top edge, and down over the outside about $\frac{1}{4}$ inch. The upper section is rasped to fit snugly within the socket, and is scraped clean about $\frac{1}{8}$ inch above the edge of the socket. The blowpipe is then applied as for making a horizontal seam in a vertical sheet.

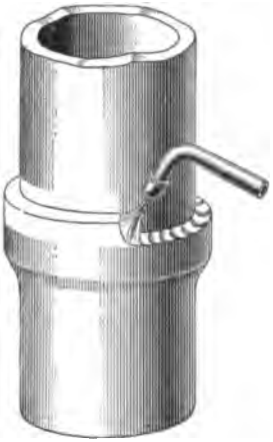

FIG. 56

61. Fig. 57 shows the mode of **burning a T joint.** Care must be taken to preserve a proper thickness of metal at *a* when opening out the hole to fit the branch. If the metal is thinned out, there is great liability of burning a hole through at that point or in being compelled to feed the flame with a lead stick.

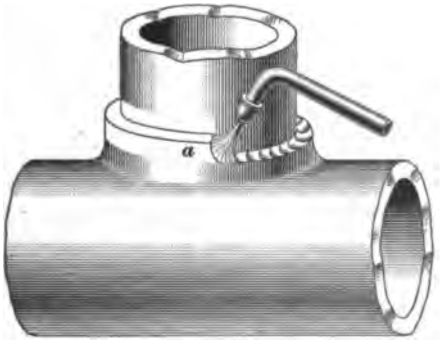

FIG. 57

In making joints in horizontal pipe, the angle of the seam varies from the horizontal at the top to the vertical at the sides, and to the inverted position at the under side. The joint should be begun at the bottom and be worked both ways toward the top.

62. When the sheet-lead lining of tanks is to be burned, the lining should be cut so as to require the least possible number and extent of joints. As many of the joints as may be practicable should be made in the bottom, because it is easiest to burn them there.

Fig. 58 shows the arrangement of the joints for a tank, say 6½ ft. × 4 ft. × 2½ ft. deep. The bottom and two sides are made of one piece, which extends to within about 3 inches of each end. Each end section is formed with a 4-inch flange around the bottom edge and each side, thus lapping 1 inch over the bottom and side sheet. The corners formed by the flanges may be closed with a miter joint lapped, as at *a*, or a horizontal seam, as at *b*. The top edges of all the vertical sheets should be lapped over the edge of the wooden tank sides and be secured with copper nails in the usual manner. When the sides of the tank are large, the sheet-lead lining must be supported at intervals by means of buttons, that is, brass screws having their heads protected by burning over them.

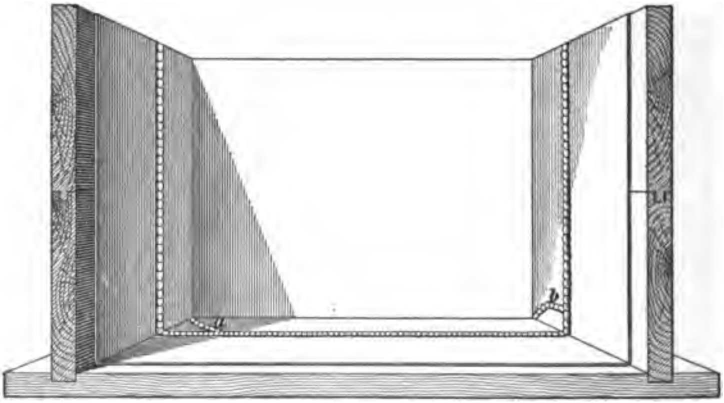

FIG. 58

63. The lead sheets are prepared for the tank in a manner similar to that previously described, due allowance being made for the flanges that are bent up on the end sheets. The body of the tank lining should first be set in place, care being taken that the bent corners should fit the angles between the sides and bottom, so that the lead will not be stretched when set home. After setting the lead well into the angles, it should all be flapped to a smooth surface with a sheet-lead flap, and be nailed over the edge of the tank. The ends of the tank are then carefully measured and it is found whether the width of the tank is the same at the top and bottom, whether the angles are right angles, and whether the sides are square with the bottom at both ends. If this measuring and testing are neglected, some very annoying misfits are likely to occur.

64. The flanges are then formed up, as shown in Fig. 59, and the corners lapped and scraped to make proper corner joints. The flanges are scraped clean on the edges *a*, and ½ inch down on the outside all the way around, and similarly about ¼ inch down on the inside. The end sheets are then lowered into place and set home snugly into the angles. The flanges should overlap the bottom and side sheet ½ inch or more at each end. The edges of the flanges are then scribed on the under sheet, and the flanges are raised to facilitate scraping the border of the under sheets so that the joint may be properly burned. The flanges are now dressed down again and the process of burning the seams begins. The flat bottom seams should be burned first, then the vertical seams, commencing from the ends of the horizontal seam and working upwards, as before described. Great care must be taken when burning the corner seams *a* and *b*, Fig. 58, that the burning is continued fully into the corner, so that no small pinhole can remain.

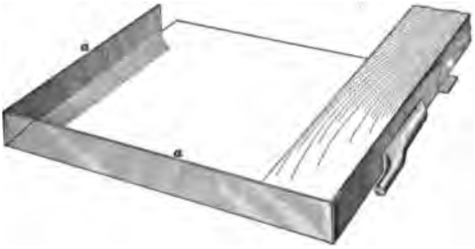

FIG. 59

PIPEWORK

IRON PIPEWORK

CAST-IRON PIPEWORK

CUTTING SOIL PIPE

1. Standard cast-iron soil pipe may be cut by first filing a groove around it and then deepening the groove with a cold chisel. If the filing of the groove is omitted, and an attempt made to cut the pipe by using only a hammer and cold chisel, there is a strong probability that the standard pipe will be split. When a soil pipe is to be cut to fit, a length of double-hub pipe should be selected in preference to single-hub pipe, since with double-hub pipe the end not desired may be used on some other job.

2. Extra-heavy soil pipe can be cut with the hammer and chisel. To cut it, draw a line neatly around the pipe at the place where it is to be cut. Lay the pipe on a solid block of wood or on a mound of earth, and, following the chalk line, cut into the pipe with a hammer and chisel, as shown in Fig. 1. A groove is thus made all around the pipe, which weakens it. Continue driving the chisel into the

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groove uniformly all around, revolving the pipe with the knee, as shown. In a short time the metal under the groove will be so ruptured that the piece will fall off, as shown in Fig. 2, making a neat square cut.

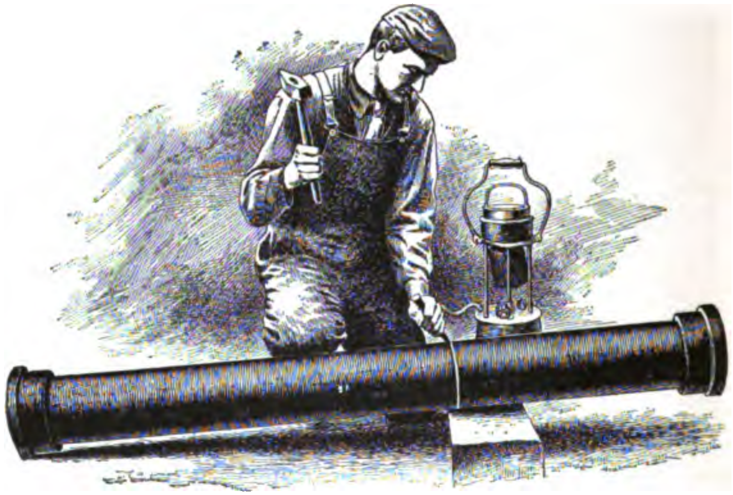

FIG. 1

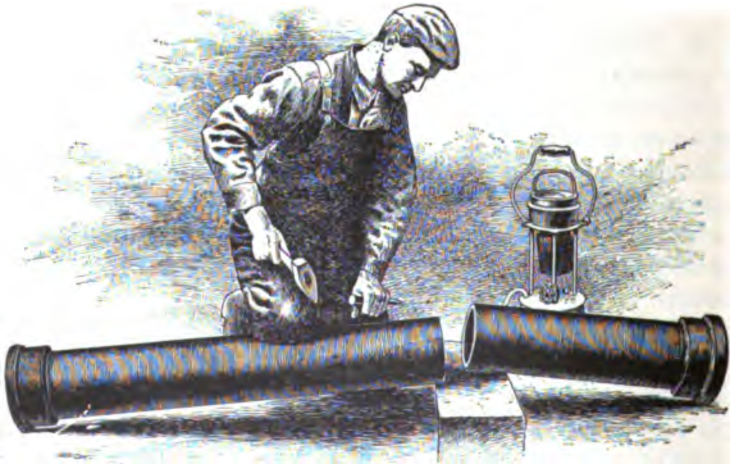

FIG. 2

3. It sometimes happens that a pipe is defective and will not cut square, breaking crooked, as shown in Fig. 3. Such a piece should not be used, but may be cut again when a shorter piece is required. Or, if circumstances permit the pipe to be shortened, say to the dotted line *a*, the end may be **chipped down,** as shown in Fig. 4. The piece of pipe is rested against the edge of an iron beam, or any other convenient hard edge, so that the line to which the end of the pipe is to be chipped comes on the edge. A piece is then broken off and the pipe revolved a little, when another piece is broken off. This operation is repeated until the end is square. The edge obtained by chipping is rough, but if well done, the irregularities need not be more than $\frac{1}{8}$ inch deep. A break like that shown in Fig. 3 is usually due to an unskilful manipulation of the tools; it does not necessarily indicate a defective pipe.

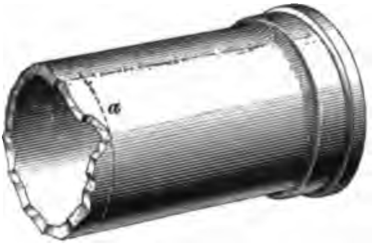

FIG. 3

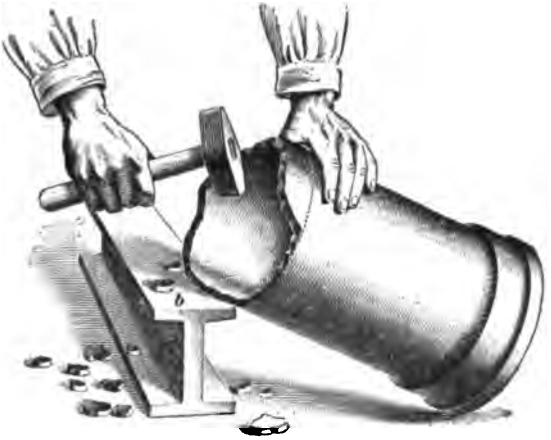

FIG. 4

4. When a pipe splits, as shown in Fig. 5, while being cut, it usually proves that the pipe is defective; a pipe thus split should be rejected.

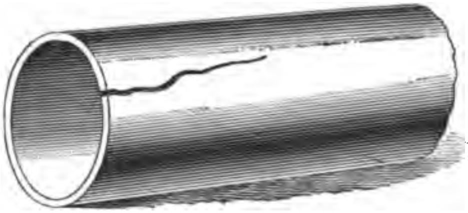

FIG. 5

CALKING JOINTS

5. Calking a Vertical Joint. To calk a spigot-and-socket joint in soil pipes, push the spigot end tightly into the socket; then, with the yarning tool, drive twisted oakum into the socket, as shown in Fig. 6. Do not cut the oakum with the edge of the tool; simply push it down. Do not bunch it at any place; set it in uniformly. When two or three strands are in (a strand being one thickness of the oakum), drive them down solidly with the hammer and a thick-faced yarning tool. Continue to insert the oakum, driving it home with the hammer periodically, until there is a space of about 1¼ inches to 1½ inches between the oakum and the face of the socket. Then, to insure that the oakum is packed into a thoroughly compact mass, give it a final driving with heavy blows of the hammer on the yarning tool.

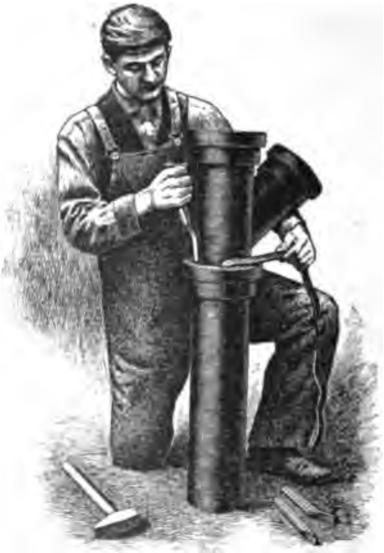

FIG. 6

6. After the oakum has been packed in, the space above it is filled with molten lead, as shown in Fig. 7, the face of the hub being held perfectly level so that the lead will not overflow on one side before the other is entirely filled. A large enough ladle should be used to allow the joint to be made in one pouring. If the socket is only partly filled at one pouring, the lead will set before more can be obtained from the pot, and the result will be an imperfect joint. Only soft pig lead should be used for this work; hard lead as obtained from old wiped joints, or lead impregnated with impurities, should not be used.

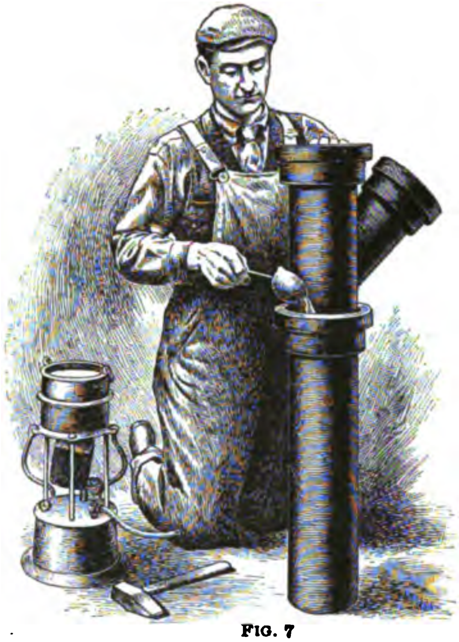

Fig. 7

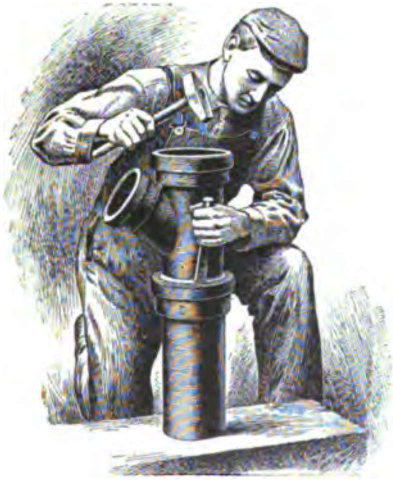

Fig. 8

7. After the joint is **run up,** that is, filled with lead, take a thick-faced staving tool and drive the lead ring uniformly into the socket, as shown in Fig. 8. This compresses the lead and makes it fill the interstices of the socket so closely that the joints will be air- and water-tight, even if subjected to high pressure. If this staving is omitted or carelessly done, the joint may not be water-tight. It certainly will not be strong enough to resist the wear and tear of service.

8. If the oakum is not thoroughly packed and driven home with a yarning tool before the molten lead is poured into the socket, the lead will drive it too far when it is calked, and the work will be defective. In a joint of an upright pipe the lead should be poured into the socket until it stands about $\frac{1}{8}$ inch above the rim, when it is just on the verge of overflowing, as shown at *a* in Fig. 9. The object of the excess of lead is to obtain a flush finish with the edge of the hub when the lead is calked; this result obtains if the oakum has been packed in solid. The stiffness and durability of the joint depend on the perfect and complete filling of the socket to the extreme edge.

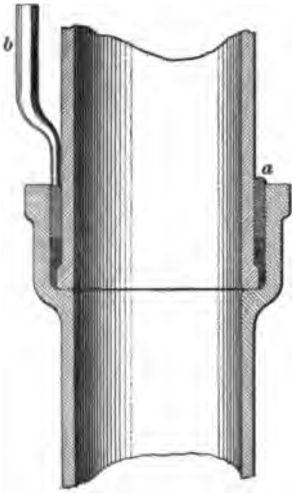

Fig. 9

9. The process of calking the lead or oakum should be begun at the most difficult or inaccessible parts of the joint, so that the lead and oakum in these parts will be compressed still more when the other parts of the joint are being calked. The staving tool or lead calking tool *b*, Fig. 9, should be run around gently the first time, and then around again with heavier blows of the hammer to drive the lead uniformly home, thus avoiding unequal strains on the socket. Each blow of the hammer increases the pressure inside of the hub, and judgment must be exercised to avoid cracking the hub by overpressure. It is well for the beginner to calk a few joints as an experiment until the sockets burst, to determine when he should stop calking.

The staving tool should not be tapered, because then it is liable to wedge between the hub and pipe, if the lead is below the edge of the hub, and strain the hub so that it will crack when the calking of the lead is about completed. A cracked socket should always be removed and be replaced by a new pipe.

10. Calking a Horizontal Joint.—In making horizontal joints, or joints on inclined pipes, the outer end of the socket must be closed by a band or joint runner, as shown at *a*, in Fig. 10 (*a*). If a special joint runner is not at hand, the band is usually made of clay and strengthened by a piece of rope embedded in the clay. A **gate**, or pouring notch, is left at the top, and molten lead is poured into it from the ladle, as shown. The working face of the clay is shaped so that the lead will take the form shown in Fig. 10 (*b*) at *b*, the projection *c* being the gate. Pouring should not be stopped until the gate is full and remains so. Particular care should be taken before pouring that the socket be wholly free from moisture; otherwise, an explosion is very likely to occur while the lead is running in, by the moisture being suddenly converted into steam. To guard against this danger, the workman should always stand behind the

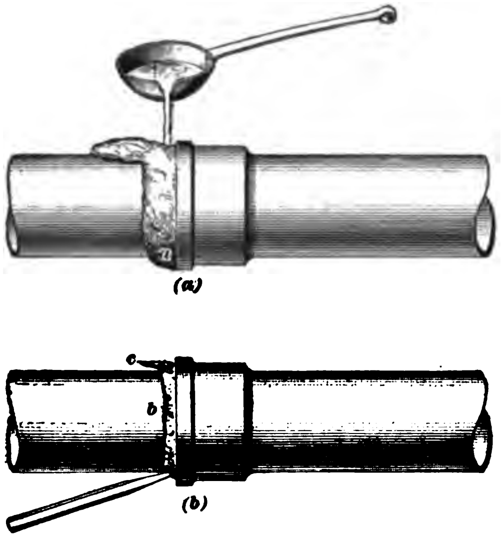

Fig. 10

hub, so that if an explosion does occur, the hot lead will be projected away from him. If it is necessary to pour lead into a damp socket, some powdered rosin should first be thrown into the socket. This will help to prevent a violent explosion. The joint runner must be tightly secured, because the pressure of the melted lead in sockets of large diameter is considerable; if it starts the band a little, the lead is liable to run out and thus spoil the joint.

11. Calking Inverted Joints. — When a joint is inverted, it is advisable to do the calking before placing the pieces thus joined in position, arranging the connections in such a manner that the pieces joined by the inverted joint can be readily connected. Fig. 11 shows how this may be done, taking for an example the junction of a vent stack *A* with a soil-pipe stack *B*. The soil-pipe stack is erected ready to receive the Y-branch fitting *a*. The latter fitting, the 45° elbow *b*, and the short length of pipe *c* are calked together before being placed into the position shown in the illustration, as the joints between them can then be placed upright for calking. When the three combined pieces are placed on the soil stack and vent stack, their joints with these pipes are upright, and consequently easily calked.

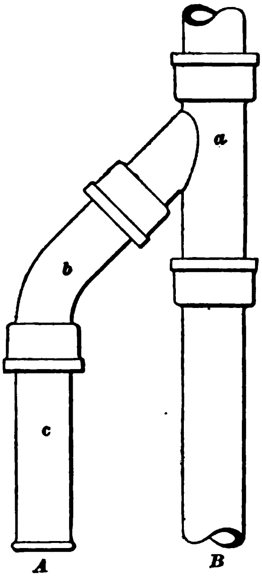

FIG. 11

12. It is inadvisable to try to calk an inverted joint in place unless special provision is made for air to escape from the socket, since otherwise an air lock will occur, as shown at *a* in Fig. 12. If the oakum *b* is calked solidly home, it will be practically air-tight. The air at *a*, therefore, cannot escape freely, and hence the lead will set before the space is filled. After the clay band *c* is removed, the lead is calked, but it will be found that the lead at *d* cannot be driven up into *a* to fill the socket entirely at this place. This part of the joint will hence be defective.

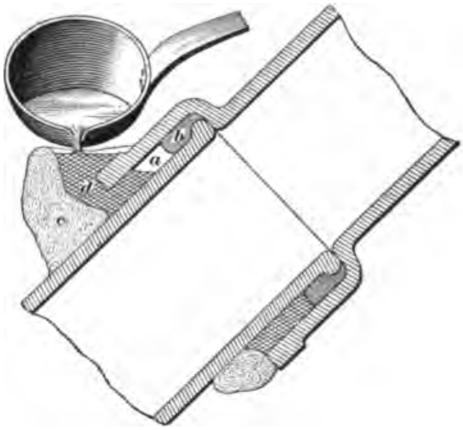

FIG. 12

13. If it is necessary to calk an inverted joint in place, a special fitting should be used that has a pouring gate cast on the socket, as shown at *a*, in Fig. 13. The air escapes through this pouring gate, as shown by the arrow, while the molten lead is running into the joint. This joint can be entirely filled with lead and pouring is stopped when the gate is entirely filled. After this joint is calked in the ordinary manner, the gate is also calked, and a solid job is thus obtained. Plumbers seldom have occasion to use inverted joints, however, because permission is generally granted in plumbing ordinances to connect vent pipes to stacks at right angles.

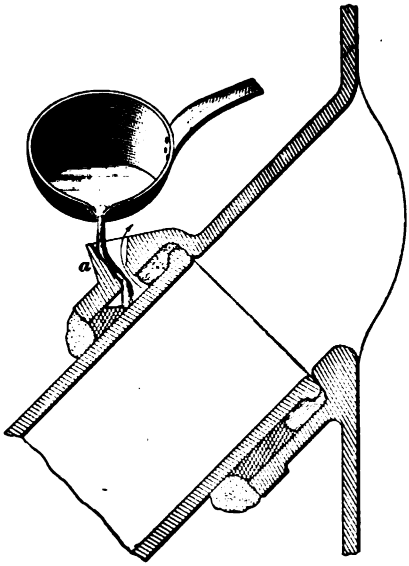

FIG. 13

14. Defective Calked Joints.—If a pipe having no spigot ring on the end is calked into a socket, there is a liability of the oakum being driven into the pipe, which tends to catch solid matter in the sewage and thus finally choke the pipe. To guard against this, make a mark on the pipe flush with the socket when it is solidly home, and before calking in the oakum; then, after calking in the oakum examine the mark before running the joint with lead to see that the pipe has not slipped out. This is most liable to occur when calking horizontal joints on the floor. Another defective joint is that in which a poorly cut pipe like that shown in Fig. 3 is used. The oakum is then driven through the irregularities, as shown in Fig. 14. This tends to choke the pipe, and is a common source of trouble due entirely to careless work.

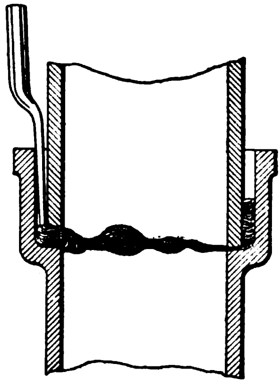

FIG. 14

15. The crooked joint shown in Fig. 15 is a common defect due to carelessness, and should be condemned on general principles. The work should be rearranged and a proper joint made; if the crooked joint is due to a defective fitting, a good one should be substituted. In a crooked joint, the oakum is liable to be driven through, as shown at *a*, and the lead is liable to run through, as at *b*, owing to the difficulty of introducing the oakum into the base of the socket.

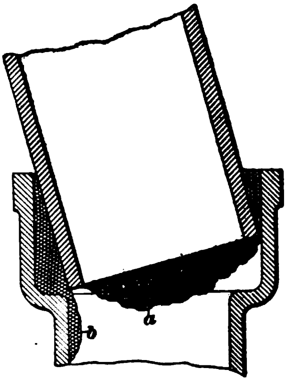

FIG. 15

16. Insertable Soil-Pipe Joint.—Plumbers often have occasion to cut a line of cast-iron soil pipe for the purpose of inserting a branch. If ordinary fittings are used for this work, it is necessary for the plumber to melt or pick out two or three joints on the soil-pipe line so as to get the fitting in position in the manner shown in Fig. 16 (*a*). This method is often very inconvenient, and always tedious. To overcome the objections, the insertable joint shown in Fig. 16 (*b*) was designed. It is simply a short piece of pipe with an extra-long hub having a collar *a* cast inside, as shown. To insert this fitting, it is only necessary to cut out of the line a piece having a length equal to the sum of the lengths of the branch fitting and the insertable joint. The latter is then slipped over the end of the pipe, as shown at *b*, Fig. 16 (*c*). The branch *c* is next inserted, and the insertable joint is slipped back into the socket of the branch. This brings the collar *a* down near the end of the pipe *d*, but not below it, when the fitting *b* is sent home into *c*. The joints can then be calked in the ordinary manner. As shown, the branch is thus inserted without disturbing the rest of the soil-pipe line. A loose lead ring, shown at *e*, is sometimes slipped over the pipe before the insertable joint is applied, and is slipped down on top of the collar *a* before the oakum is calked into the joint. This is intended to positively prevent oakum from being driven down beyond the collar *a*, which collar may fit the soil-pipe line rather loosely.

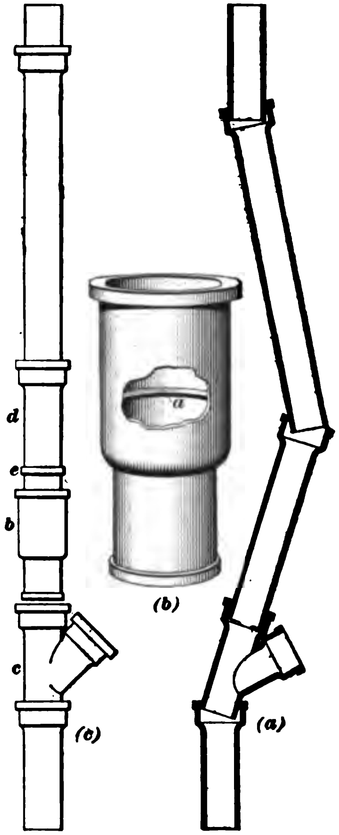

FIG. 16

WROUGHT-IRON PIPEWORK

INTRODUCTION

17. Wrought-iron pipes form a considerable part of modern plumbing systems. For instance, water-supply pipes in many localities are chiefly galvanized wrought iron or steel. Drainage and ventilation pipes, also, are frequently of wrought iron. Hence, the plumber must be familiar with wrought-iron pipe work.

To facilitate the work, the pipe-fitter's bench must be made solid by braces or bolts. A flimsy bench or loose pipe vise prevents the fitter from doing good work, besides compelling him to exert considerably more energy than is otherwise necessary for cutting and threading pipes.

CUTTING PIPE

18. Wrought-iron pipe up to 2 inches in diameter is commonly cut by means of the ordinary wheel cutter. The pipe is placed in the vise, and the cutters are applied at the proper place. The wheels are then squeezed into the pipe little by little as the tool is revolved around the pipe, until the piece falls off. In applying three-wheel cutters, care must be taken to hold the tool square with the pipe; if this is not done, the wheel will cut several grooves instead of one, and if the wheels slip from one groove to another, their edges are likely to break. Single-wheel cutters are free from this liability, but do not cut the pipe as fast. Three-wheel cutters are particularly convenient for cutting pipes in close places where it is impossible to swing the tool entirely around the pipe. The cut ends should be examined to see whether any cracks or splits have been started by the cutting operation.

19. Pipes that are to be screwed into flush fittings, and there make butt joints, must have their ends squared either in a lathe or in a suitable cutting-off machine, after they have been cut. Unless the end is perfectly square with the axis of the screw thread, it will be impossible to make a good joint against the shoulder of the fitting into which it is screwed.

20. When cutting pipe that is coated internally with enamel or glass, great care should be taken to avoid chipping or cracking the coating or lining. The wheel pipe cutter should never be used in cutting this kind of pipe. The only kind of cutter that may properly be used is one that cuts like a lathe tool, leaving the end of the pipe square and true; if carefully used, it does not crack or peel off the brittle lining.

21. The larger sizes of wrought-iron pipe should be cut off either in a lathe or by a cutting-off machine. Oil should be used freely in cutting pipe, and the wheels of the cutter should be kept sharp, since, if their edges are dull, they will not wedge apart the metal forming the pipe, but will force a large part of it inwards, thereby reducing the bore of the pipe at this point by forming a large burr, as shown at *a* in Fig. 17, which will reduce the flow of water through it. Even if the wheels are kept perfectly sharp, a burr will be formed, but it will be much smaller than in the case of dull wheels. On all good work the burr should be removed.

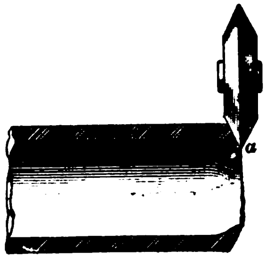

FIG. 17

REAMING

22. Reaming is the process of removing the burrs from the cut ends of pipes. The tools used for this purpose are called **reamers,** and are conical in shape; if properly proportioned, the length of the reamer, or the altitude of the cone, will be about twice the diameter of the base, as shown in Fig. 18, which represents a **hand reamer.** The convex surfaces of reamers are formed into a series of sharp teeth converging toward the apex. By pressing the reamer into the orifice of the pipe and revolving it, the teeth cut off the burr and form the internal surface of the orifice into the frustum of a cone. There are reamers on the market for attaching to the stocks or dies so that the pipe may be reamed while the thread is being cut.

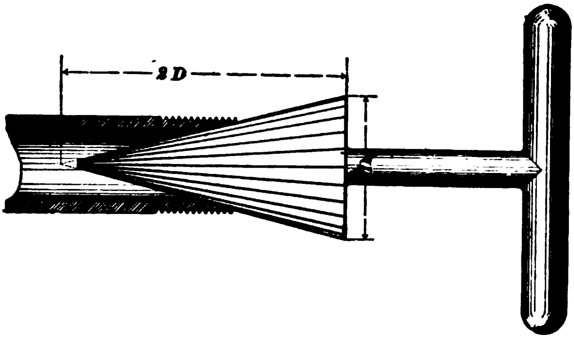

FIG. 18

CUTTING THREADS

23. The tightness of a screwed joint depends largely on the accuracy with which the thread is cut. A good thread is shown in Fig. 19. The part *a* contains the **leading threads,** which are perfect in form. These are depended on chiefly for making a close contact with the thread in the fitting, and thus insuring a water-tight joint. The threads at *b* are imperfect. Their tops are flat and they only serve to make the joint rigid, unless their form be changed by the pressure exerted in screwing the pipe into a socket or fitting.

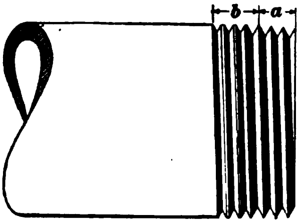

FIG. 19

24. Occasionally a groove runs lengthwise in a wrought-iron pipe; this prevents a perfect thread being made. Such pipes should not be used on high-pressure work. On low-pressure work, however, they may be used, provided that they are screwed up with red-lead cement and hemp wrapped over the thread. These materials will fill the interstices, and usually make them water-tight.

25. When it is necessary to thread a piece of pipe that is too short to be held in the vise, a **nipple chuck,** or **nipple holder,** is used. This is simply a pipe coupling screwed over the end of a piece of pipe long enough to be held in the vise. The short piece, or nipple, should be screwed into the coupling until it butts against the end of the longer pipe, as this prevents swelling and splitting of the coupling. After a long nipple has been cut, it can be unscrewed with a pipe wrench; to remove a close nipple from the nipple chuck, the coupling should be unscrewed a little from the piece held in the pipe vise, when the nipple can be screwed out with the fingers. When close nipples are to be cut, the threaded end should enter the coupling a little less than the length of the perfect threads, and then butt against the piece held in the vise.

TABLE I

SCREW THREADS FOR WROUGHT-IRON PIPE

Nominal Internal Diameter in Inches	Number of Threads Per Inch	Length of Perfect Thread in Inches	Nominal Internal Diameter in Inches	Number of Threads Per Inch	Length of Perfect Thread in Inches
⅛	27	.19	2	11½	.58
¼	18	.29	2½	8	.89
⅜	18	.30	3	8	.95
½	14	.39	3½	8	1.00
¾	14	.40	4	8	1.05
1	11½	.51	4½	8	1.10
1¼	11½	.54	5	8	1.16
1½	11½	.55	6	8	1.26

All pipe ends are made conical, the taper being ¾ inch of diameter per foot of length.

26. The majority of manufacturers of wrought-iron pipe have adopted the **Briggs standard** system of screw threads for pipe and fittings. A few manufacturers, however, do not conform to it strictly; they use 12 threads per inch instead of the 11½ threads called for in the table.

To make perfect joints with standard fittings, the perfect threads should be cut to a certain distance only from the end of the pipe. This distance is stated in Table I.

SCREWING ON FITTINGS

27. In order to make sure of having a water-tight joint, it is customary to paint the perfect threads (seldom more than three or four) on the pipe and in the fitting with red-lead, or other, cement before entering the male thread. Because the thread is tapering, the pipe or the fitting starts easily and the cement stays where put. If the red lead is sparingly applied, little, if any, will show outside, or be pushed inside by the operation of screwing up. Care must be taken not to overload the female thread with red lead, and not to screw up fittings too tight, for they may split. The proper point to stop screwing up can only be determined by experience. In screwing on valves or other brass fittings, whether plain, finished, or nickel plated, the wrench should always be applied to the hexagon shoulder provided for the purpose. This will prevent the brass fitting from being distorted.

BENDING WROUGHT-IRON PIPE

28. Small sizes of pipe, such as 1-inch or less, are usually bent cold over a block or mandrel. Larger pipes, however, are heated to redness and then bent over a curved block, or better still, over an iron wheel having a groove to receive the pipe and prevent its sides spreading while being bent. The weld, or seam, of the pipe should always be kept on the inside of the curve, to prevent splitting the pipe. Only black pipe should be bent. If galvanized pipe is bent cold, the zinc coating often breaks or chips off, and if bent hot, the zinc is vaporized by the heat and the protective coating thus spoiled.

MEASURING FOR PIPING

29. When taking **measurements for piping,** the center-to-center distances of the different pipe lines are measured first, and then allowance is made for the fittings. Fig. 20 (*a*) shows a sample of pipework composed of four elbows, one tee, two valves with wheel handles, and seven pieces of pipe. Where a valve is placed in a pipe, it is customary to consider the two pieces of pipe to which it is attached, and the valve, as one piece; this accounts for the statement that there are seven pieces of pipe. The dimensions marked *a*, *b*, *c*, *d*, and *e* are measured, and transferred for reference purposes to a sketch similar to that shown in Fig. 20 (*b*). In locating the valves, it is customary to use a ready-made nipple on one side, and then to cut a piece for the other side sufficiently long to obtain the proper length of *b* or *c* when the whole is screwed up.

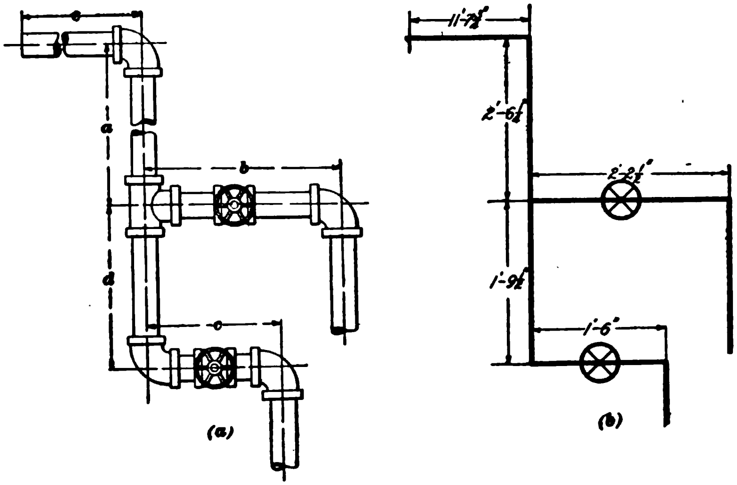

FIG. 20

30. In measuring for 45° fittings, the plumber must exercise considerable care. He may place the fittings in position and measure between them, using try pieces *a*, *a*, as shown in Fig. 21, which point straight toward each other, thus obtaining the measurement *b*, which will be the length of pipe required. In case, however, that it is inconvenient to do this, the exact measurement across at *c* may be taken, which if multiplied by 1.4142 will give the length of the diagonal line from center to center of the 45° fittings. From the length thus found must be subtracted the distances between the ends of the diagonal pipe and the center of the fittings.

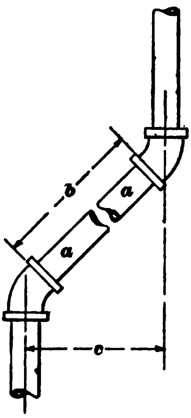

FIG. 21

EXAMPLE.—What length of pipe is required at *b*, Fig. 21, assuming that 1 inch is allowed between each end of the pipe and the centers of the fittings, and that the distance *c* is 4 feet 9 inches ?

SOLUTION.— 4 ft. 9 in. × 1.4142 − (1 + 1) = 57 × 1.4142 − 2 = 78.6 in., or 6 ft. 6½ in., fully. Ans.

31. A simple method for finding the diagonal length is as follows: Strike two parallel chalk lines on the bench or floor to represent the center lines of the pipes to be joined by the diagonal piece, as *a b* and *c d*, Fig. 22. Lay a steel

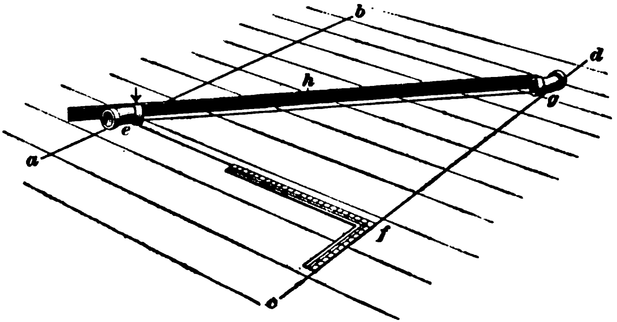

FIG. 22

square against one of these lines, as shown, and draw a perpendicular *e f*. From the intersection at *f* on *c d* lay off a point *g*, making *f g* equal to *e f*. Draw a line through *e* and *g*. Then lay a 45° fitting over each of these intersections and measure with a rod *h*, as shown, the length of pipe required.

BRASS, COPPER, AND EARTHENWARE PIPEWORK

BRASS AND COPPER PIPEWORK

HOLDING THE PIPES

32. Brass and copper pipes of iron-pipe size are handled the same as iron pipe, excepting that more care is exercised in preserving the surface of the pipe from being damaged by the jaws of the pipe vise or the pipe wrenches. While pipe tools used for gripping iron pipe have teeth that cut into the pipe, the tools used for brass or copper pipe should grip the pipe only by friction, so that the pipe will not be marked by the vise or the other tools.

33. Friction clamps made as shown in Fig. 23 are used for fixing a pipe in the pipe vise. The clamps *a* and *b* are made to fit the jaws of an ordinary vise, and the curve is formed to fit a standard size of pipe. The curve is lined with rubber or some other soft body. The pipe-vise jaws compress *a* and *b* and the pipe then cannot slip. The clamps are made long so as

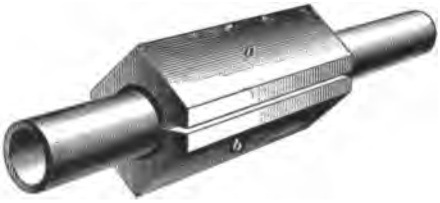

FIG. 23

to spread the pressure over a large area of pipe and thus prevent its flattening. Fig. 24 shows how a plumber can make his own friction clamps. A common iron-pipe coupling is sawed into equal parts *a* and *b*, and then lined with thick sheet-lead pieces *c*, *d*. They grip the pipe like *a* and *b*, in Fig. 23, but with heavy pressure from the pipe vise these clamps are liable to spread. Powdered rosin is usually sprinkled in these clamps to prevent the pipe slipping. This can be washed off the pipe with kerosene oil after the threads are cut. If the pipes are nickel plated, care must be taken to prevent their slipping in the clamps; otherwise ugly rings will be scratched around the pipe, which indicates careless workmanship.

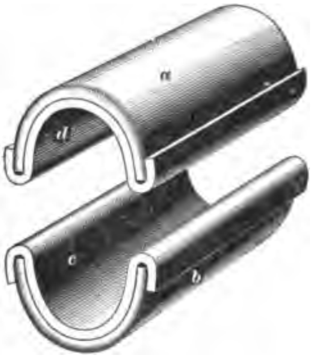

FIG. 24

THREADING BRASS AND COPPER PIPE

34. In **threading brass or copper pipe,** particular care should be taken to revolve the dies with a uniform motion. This prevents splitting the pipe, and allows the dies to cut slowly and evenly, which helps to prevent the thread from being ragged or chewed away in places. Particular care should be taken, in threading nickel-plated pipe, to make the threads just long enough to be all hid in the fitting, as shown at *a* in Fig. 25, instead of having them too long and allowing a few threads void of plating being visible, as at *b*. The former indicates neat, skilful workmanship.

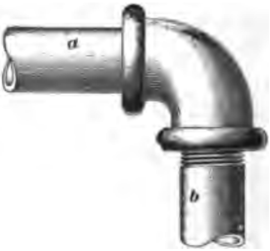

FIG. 25

The neat finish shown at *a*, Fig. 25, is readily obtained by the use of **recessed fittings,** which allow some of the plain part of the pipe to slip into the socket, as shown at *a* in Fig. 26. The liability of having threads show when the fitting is screwed up is thus avoided.

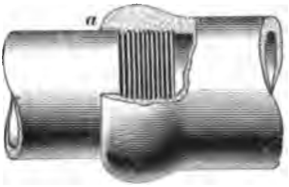

FIG. 26

35. Thin brass tubes, such as are commonly used for flush pipes, waste pipes under wash basins, etc., are cut with a hack saw, and then threaded with special dies having a larger number of threads (27 to the inch) than ordinary iron-pipe dies. Special **fine thread fittings** are used for such tubes.

36. In threading nickel-plated pipe, a wrapping cloth or paper should be placed between the guide and the pipe, in order that the guide will not mark the pipe as it revolves.

SCREWING UP FITTINGS

37. The best way of **screwing up** such fittings as elbows and tees, is to screw a short piece of pipe into the fitting and to use it as a lever. After the fitting is screwed home, the piece of pipe is removed. As brass fittings yield quite easily, owing to their comparative softness, there is a danger of seriously distorting them if they are screwed home by the aid of a pipe wrench or monkeywrench.

38. Fittings that are furnished with hexagon shoulders should be screwed up by applying a monkeywrench to the hexagon, placing a piece of cloth between the jaws of the wrench and the nickeled surface. A wrench with teeth should never be used for nickel-plated brass or copper work. The joints of brass and copper pipes are usually put together with red or white lead in the threads. When they are to be soldered, or **sweated,** as it is called, the threads should be tinned with half-and-half solder, and while hot screwed up tight before the solder has time to set. A torch flame is used for heating the work, which is tinned by rubbing it while hot with a strap of solder.

BENDING BRASS AND COPPER PIPE

39. Before attempting **to bend brass or copper pipe,** it should first be annealed, that is, made red hot, and then plunged into cold water. This softens the pipe and makes it easier to bend. Common water pipes (iron-pipe size) having diameters less than 1 inch are bent cold over a grooved block, in the same manner as iron pipe. Larger sizes, however, after annealing are filled with melted rosin and then bent over a form when cold. The rosin having solidified in the pipe, prevents its collapsing while being bent. After the proper shape is obtained the pipe is again heated to melt the rosin, which is allowed to run out. Sometimes the pipes are filled with melted lead, while some people use sand for filling the pipe.

40. Nickel-plated pipes should not be bent after they are plated. They should first be bent to suit their respective positions and then nickel plated, since nickel plating usually cracks at the bends when an attempt is made to bend nickel-plated pipe. In bending brazed tubing, the seam should always be on the inside of the bend, because it is more brittle than the other parts, and being weaker, it may open out if placed anywhere else.

EARTHENWARE PIPEWORK

LOCATION AND CUTTING PIPE

41. Earthenware pipes should never be used inside of or under buildings; in fact, all plumbing ordinances prohibit their use in such places. They should only be used for underground work outdoors, and then only in ground that will not settle. Made ground, that is, ground made by filling in with ashes and earth, is sure to settle, and in doing so, break the pipes.

42. To cut earthenware pipe, lay it on a mound of soft earth and then cut a groove all around the pipe with a sharp cold chisel and a light hammer.

MAKING JOINTS

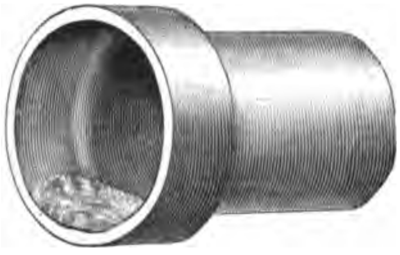

FIG. 27

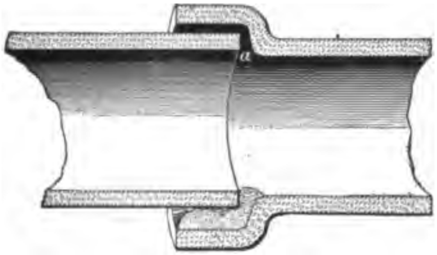

FIG. 28

43. To make good joints in earthenware pipes, place some cement (half Portland cement and half clean sand) in the bottom of the socket, as shown in Fig. 27. Then enter the spigot end of the pipe about to be laid into the socket, as shown in Fig. 28. When the spigot end is pushed hard against the socket shoulder at *a*, let it down on the cement. Beat it down gently with a wooden tool, the hammer handle, for instance, until it is in the center of the socket. This presses the superfluous cement out of the socket and insures the bottom, which is the most important part of such a joint, being tight. The entire joint should then be carefully cemented water-tight. When this is done, a wooden scraper is pushed inside the pipe, and any cement that may have worked inside is scraped out, as shown in Fig. 29. This figure shows a well-made joint that will be perfect after the loose cement *a* is removed.

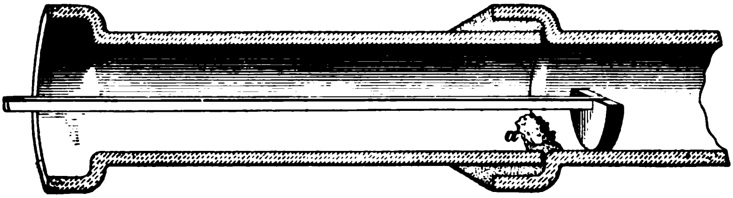

FIG. 29

44. Fig. 30 shows a very common defective joint, where cement projects on the inside, as at *a*. This defect generally occurs when a whole line of pipes is first laid in a trench and then jointed. The proper method is to cement and finish each length of pipe as soon as laid. If joints must be cemented after the entire line of pipes is laid, it is advisable to calk two strands of oakum into the socket before the cement is applied. This will prevent the cement from running into the pipe. It will also help to center the spigot in the socket.

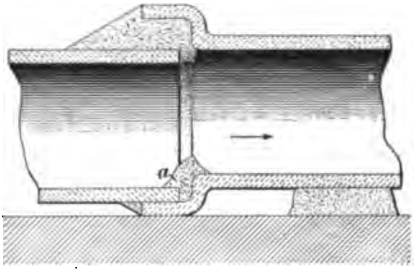

FIG. 30

TABLE II

SPACING FOR TACKS

Size of Pipe in Inches	Distance Apart in Inches			
	Vertical Pipe		Horizontal Pipe	
	Hot	Cold	Hot	Cold
3/8	18	24	12	16
1/2	19	25	14	17
5/8	20	26	15	18
3/4	21	27	16	19
1	22	28	17	20
1 1/4	23	29	18	21
1 1/2	24	30	18	22

PIPE SUPPORTS

SUPPORTING LEAD PIPES

TACKS, BANDS, COLLARS, AND LEDGES

45. Lead pipes 2 inches in diameter and less, which run against walls, etc., are usually supported by means of flanges, or **pipe tacks,** which are soldered on to the pipe at convenient intervals, and are fastened to the walls with common wood screws, as illustrated in Fig. 31, which shows a ¾-inch lead pipe *a* secured to a wall or pipe board *b* by molded pipe tacks *c*, *c* and 1-inch wood screws *d*, *d*, etc. The tacks are made of old lead, slightly hardened with a few old wiped joints mixed in. They are cast in brass molds and can be bought from dealers of plumbing material.

The approximate spacing for tacks on lead pipes is given in Table II.

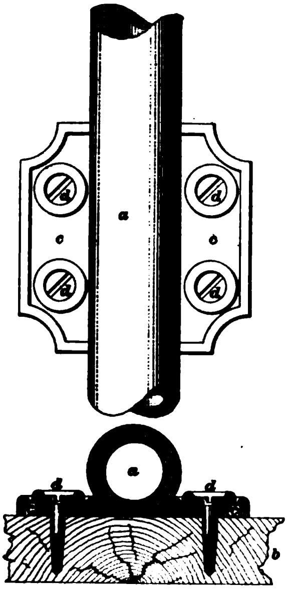

FIG. 31

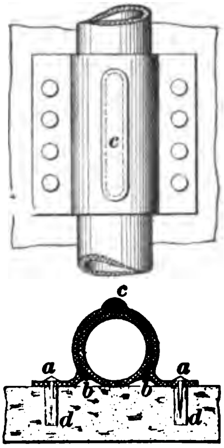

FIG. 32

46. Pipes over 2 inches in diameter are best supported by means of broad **bands,** such as are shown in Fig. 32, which are attached at intervals of about 3 or 4 feet. The width of the bands, along the line of the pipes, measured for pipes of 2, 3, or 4 inches diameter, should be about 6, 8, or 10 inches, respectively. An oblong hole *c* is cut in the front of the band and is filled with hot solder and wiped to the face of the pipe. The side flanges of the band are wiped to the face of the pipe, as shown at *b*. The band is shown secured to a stone wall by flathead spikes *a*, driven into wooden plugs *d*, which have been previously driven into holes cut in the stonework.

47. Vertical pipes of lead are usually supported, where they pass through floors, by means of a flange, or **collar,** which is wiped to the pipe; or a flange joint is made at that point. The diameter of the flange should be about 2 inches larger than that of the pipe, to give room for wiping.

48. When a hot-water pipe runs horizontally, it is best to support it upon a continuous **ledge,** or shelf. It should have room enough laterally to bend and creep, and should be kept from working off the shelf by a suitable rim or flange along the edge of the shelf.

49. Lead pipes should not be supported by iron wall hooks or similar supports, unless they are protected by an extra thickness of sheet lead between them and the iron, because the edges of the iron will gradually cut into the lead and thus weaken the pipe.

INFLUENCE OF TEMPERATURE

50. If the temperature of a lead pipe that is supported by rigid fastenings is maintained nearly uniform, as in the case of the cold-water supply pipes, the pipe can only be changed in form by its own weight, the jarring of the building, etc.

If, however, the temperature of the pipe is variable, as in the case of the pipes that supply hot water to the plumbing fixtures, the pipes will expand as the temperature increases, which causes them to bulge between their supports. If the pipes are vertical, they will bulge either from the wall against which they are secured or parallel to it. If they are horizontal or inclined, they will always bulge downwards and form pockets or sags. Lead is so very low in elasticity that when the pipe becomes cool, the sags are not entirely taken up by contraction, and upon every application of heat the sags will increase in size, particularly on horizontal pipes, until the lead becomes so thin near the points of support as to cause a leak. The leak generally occurs in a crack that is formed around that part of the pipe near the tacks.

Suppose that a lead waste pipe 2 inches in diameter, secured in a vertical position against a wall by hard metal tacks or lead bands, has a kink in it, and that hot water passes through the pipe periodically. It will be found that since the kink is the weakest part of the pipe, it will take up most of the expansion between the tacks on each side of it. This action subjects the kink to a cross-strain, repetitions of which will soon overcome the cohesive strength of the lead and cause the metal at that point to crack. Kinks should be carefully avoided in all lead pipework. A kink in a lead waste pipe is a positive sign of slovenly, careless, or ignorant workmanship, and should not be tolerated.

SUPPORTING IRON AND BRASS PIPES

IRON AND BRASS PIPE SUPPORTS

51. Wrought-iron pipes may be fastened in place by common drive hooks, but where a good appearance is desired, they should be fastened with bands, which are secured to the walls by screws, as shown in Fig. 33. The band, or strap, *a* should be made of wrought iron tinned.

Brass pipe may be similarly supported, making the bands of brass. It is usually supported, however, by specially made clamps or pipe hangers, which are first attached to the walls, the pipe being afterwards laid in them and locked there by closing the outer half of the clamp, which is hinged to the main body. Such supports usually hold the pipe at a little distance from the walls; this prevents vermin from lodging around it, and also allows it to be polished conveniently.

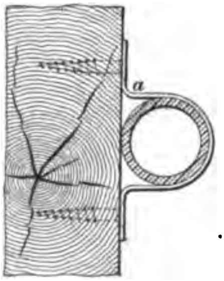

FIG. 33

SUPPORTING CAST-IRON PIPES

52. Cast-iron soil and vent pipes should be strongly secured in place. Vertical stacks should rest on a solid support at the bottom. If an elbow occurs at the base of the stack, it should be provided with a flat foot, or **heel rest,** as shown at *a* in Fig. 34.

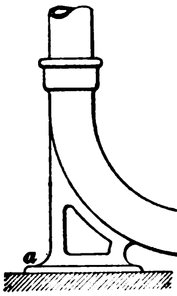

FIG. 34

The weight of the pipe should be borne entirely by the base support. The pipe should be held in place by means of hooks or bands, which are placed at intervals of 5 feet or less, according to the nature of the work.

53. The pipe may also be secured against the face of a stone wall by means of a wrought-iron band *a*, as shown in Fig. 35. Two holes *b*, *b* are cut in the stone, and the ends of the band are calked in the holes with lead. This style of fastening is neat and reliable.

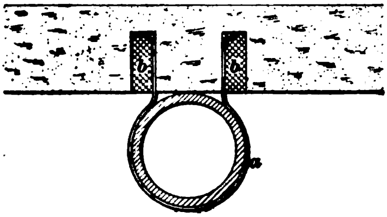

FIG. 35

All hooks or bands should clasp the pipe close under the hub, or around it, and should not be placed midway between the joints, if it is possible to avoid it.

54. If the pipes stand in a chase, or groove, in the wall, they may be fastened by means of clamps, or **pipe rests,** *a*, which are secured in notches *b*, *b* cut in the wall, as shown in Fig. 36.

Care must be taken that the fastenings are so arranged that the pipe will be free to contract and expand with the changes of temperature without loosening itself, or tearing the fastenings loose from the walls. Buildings are always liable to settle, and this must be kept in mind when locating the pipe fastenings.

Iron drain pipes that run inside of basements or cellars should be thoroughly supported by wrought-iron straps fastened to the beams overhead, or else they should be supported at short intervals on brick piers or iron standards, or by wall hooks driven into the brick or stone walls.

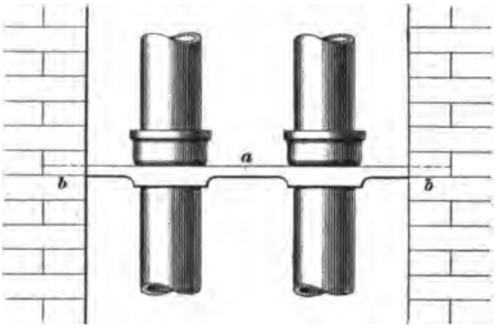

FIG. 36

A substantial pier should always be placed under each stack. In all cases a firm support, such as a brick pier or iron corbel, should be placed under the junction of the stack with the inclined drain pipe. All stacks should be supported independently of the main drain, so as to relieve the inclined pipe of the weight of the stack.

FASTENING DEVICES FOR STONEWORK

55. In pipework, as well as in other work connected with plumbing, it often occurs that pipe hangers and other apparatus are to be fastened to stonework by means of bolts, or rods are to be fastened to stonework for various purposes.

A hole about ½ inch larger than the rod is first cut or drilled in the stone to a suitable depth, which will vary with the nature of the work, a common depth being from 4 to 6 inches. The end of the rod is notched or roughened in some way; it is then inserted in the hole, and the space around it is filled with a suitable cement, such as melted sulphur. If the connection is exposed to the weather, the exposed part of the iron should be coated with asphaltum or other waterproof compound.

The rod may also be secured by filling up the hole with molten lead and finishing by calking the lead. Care must be taken in calking to avoid splitting the stone. The junction of the lead and iron generates a chemical action that corrodes the iron and gradually eats it away. This may be prevented by coating the exposed part of the iron with asphaltum.

56. Bolts may be secured to marble or slate slabs by the method shown in Fig. 37.

A hole is drilled in a slab *a* to the required depth, and is enlarged at the inner end, as shown, by means of suitable chisels. After the bolt is placed in the hole, molten lead is poured around the bolt. The lead is then gently calked. If the lead is calked too much, the marble will break away, as shown by the lines *s*. Plaster of Paris is also used to fill the space around the bolt in cases where but little strain is likely to be put on it.

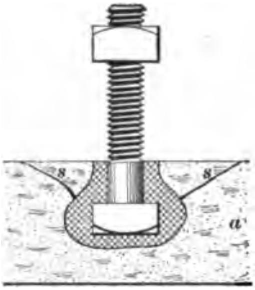

FIG. 37

57. Attachments may be made to stonework by means of expansion bolts, as shown in Fig. 38. These bolts are provided with a loose ring *a*, having its lower edge beveled, and a notched ring *b* of soft metal. A hole is drilled in the stone large enough in diameter to fit the bolt closely, and the bolt is pushed in to the depth required. The nut *c* is then screwed down and the ring *a* is forced into the end of the soft ring *b*, which is thereby expanded against the sides of the hole. These bolts are less liable to split the stones than those that are calked with lead, because the directions of the forces exerted in securing this bolt are mainly in directions parallel with the surface of the slab and in the middle of its thickness, as shown by the arrows.

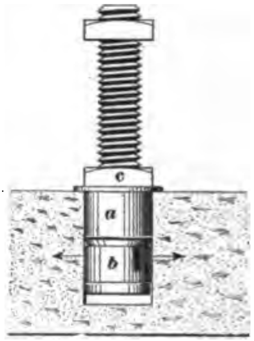

FIG. 38

WASHING AND DRINKING FIXTURES

CONSTRUCTION AND INSTALLATION

INTRODUCTION

MODERN PLUMBING

1. In modern plumbing all work as far as feasible is **open,** that is to say, the pipes and fixtures are exposed to view as much as circumstances permit. In places where the piping cannot be exposed, it is made accessible by easily removable **pipe boards,** which allow repairs and changes to be made in the piping without damage to the building. As the fixtures are not boxed in with woodwork, they can be easily kept clean and repaired; hence, they are better from the sanitary standpoint in every respect.

Formerly it was the common practice to encase all fixtures in woodwork finished and ornamented in various ways; this practice, however, has been abandoned in favor of the more sanitary and more sightly open work.

2. Plumbing fixtures consist of all kinds of sinks, laundry or wash tubs, lavatories or wash basins, drinking fountains, bath tubs, urinals, water closets, and latrines. All plumbing fixtures in buildings are or should be connected with water pipes that supply them with either hot or cold water, or both, and should be connected to waste pipes to

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drain the water or other refuse matter from them when necessary. The pipes supplying the water are known as the **supply connections,** and the pipes draining the fixtures as the **waste connections.** In combination with water closets, latrines, and urinals that receive their water supply from a tank overhead, the supply or inlet connections are known as **flush connections,** and the outlet or waste connections as **soil connections.**

SINKS

CLASSIFICATION

3. There are several varieties of sinks, viz., *kitchen sinks*, *butler's pantry sinks*, *slop sinks*, and *wash sinks.* They are made of wood, cast iron, steel, enameled iron, brown-glazed earthenware, porcelain, soapstone, slate, etc. All sinks should be provided with a strainer and waste pipe. The waste pipe should be trapped if it extends to a drain pipe or cesspool; even if it is open to the air at the end, it should be trapped to prevent the wind from blowing foul odors back into the house.

KITCHEN SINKS

4. General Instructions.—Sinks that are placed in a kitchen are known as **kitchen sinks.** They should be situated where there is plenty of light, and as near to the pantry as possible, so as to save steps for the persons using them. They should be such a distance from the range that the persons using them will not be subjected to the heat of the fire, and should be set near a window, if possible, to secure plenty of light and ventilation. Sinks should not be encased in woodwork, but left exposed all around, so that no damp places can be maintained. Care should be taken to avoid leaving any crevice or cranny where dirt can lodge or where vermin may breed. If the sink is furnished with a back of any material, the space behind it should be thoroughly filled with cement or plaster of Paris, or it may be left open for access to, and ventilation of, the parts.

Kitchen sinks should be supported by legs, or placed upon substantial brackets, at a height of about 30½ inches above the floor; i. e., from the floor level to the top or rim of the sink.

5. Wooden Sinks.—Wooden sinks are made of well-seasoned, first-class quality, heart-stock wood. It should be free from knots, splits, sapwood, and other imperfections. The best quality of white pine about 2 inches thick is preferred, and the entire woodwork should be thoroughly soaked in boiled linseed oil and permitted to dry before water is allowed to run into the sink. The oil will preserve the material, close the pores, and prevent their becoming filled with organic matter, such as grease, which will decompose and emit offensive odors.

6. Fig. 1 shows the general construction of a wooden sink. The bottom boards *a* and side boards *b* are let ½ inch into the end boards *c*, as shown at *d*, *d*. The bottom is also let into *b*. The joints are all painted and bedded with red- or white-lead putty, and the boards are securely spiked together with 4-inch galvanized-iron or brass nails. In constructing this style of sink, the carpenter should cut the **waste hole** in the bottom near one end, as shown, making the countersunk part at least 4 inches in diameter and ¼ inch deep, and the hole just large enough to fit the trap.

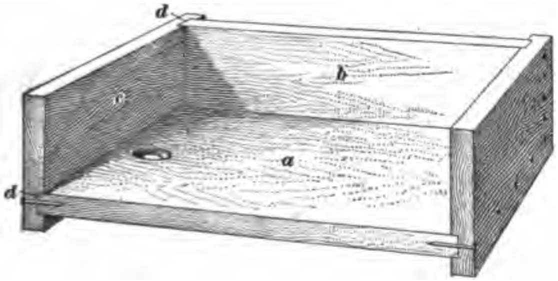

FIG. 1

7. A detail of a common form of waste connection is shown in Fig. 2. The **waste pipe** *a* is made of lead, and is flanged over and secured with copper tacks. The **strainer** *b* is made of sheet copper, and is sunk flush with the bottom of the sink. The connection is made water-tight by setting the flanged end of the pipe in red or white lead. This connection can be strengthened by wiping a flange around the pipe at *c*, and fastening it to the woodwork.

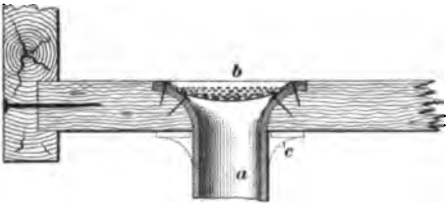

FIG. 2

Although wooden sinks and the waste-pipe connection to them are illustrated and described, their use is not recommended, because the wood absorbs foul matter that soon decomposes and evolves disagreeable odors. Wooden sinks also tend to propagate vermin.

Wooden sinks may be lined with sheet metal, preferably copper, weighing 16 to 20 ounces per square foot. The bottom must be secured at several points by solder dots, to prevent bulging when heated.

8. Pressed-Steel Sinks.—Of late years there have been placed on the market sinks pressed into shape from one piece of steel, all the corners being rounded and the top edge flanged over about 1 inch. They can be obtained painted or galvanized. They are used only on the very poorest class of work, as they corrode rapidly, and owing to the extreme thinness of the metal, they become useless. These sinks are not to be recommended, unless

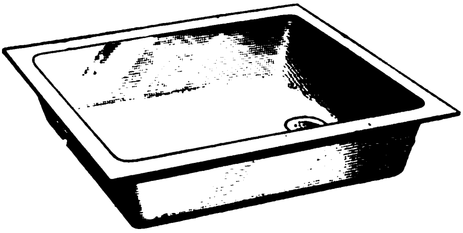

FIG. 3

they are made of metal at least 1/8 inch thick. Fig. 3 shows the common form of pressed-steel sink having the strainer at one end. The bottom pitches down about 1/4 inch to the strainer when the flange is set level.

9. Fig. 4 shows how a suitable **frame support** for a pressed-steel sink may be made and secured in place. Cleats *a*, *a*, *a*, 3 or 4 inches wide by 2¼ inches thick, are nailed to the wall at a height of 2 feet 6 inches above the floor, to support the back flange of the sink. The cross-pieces *b*, *b'* support the end flanges, and the strip *c* supports the front flange. The strips *d*, *d*, *d*, *b'*, support a **drain board** at the left-hand end of the sink. These pieces just mentioned are constructed with a pitch toward *b'*, of at least 1/4 inch to the foot, so that water may drain from the board into the sink. All the strips except *a*, *a*, *a* are about 1¼ inch thick. Strong iron **brackets** *e*, *e*, *e*, secured to special blocks at the back of the wainscoting, support the

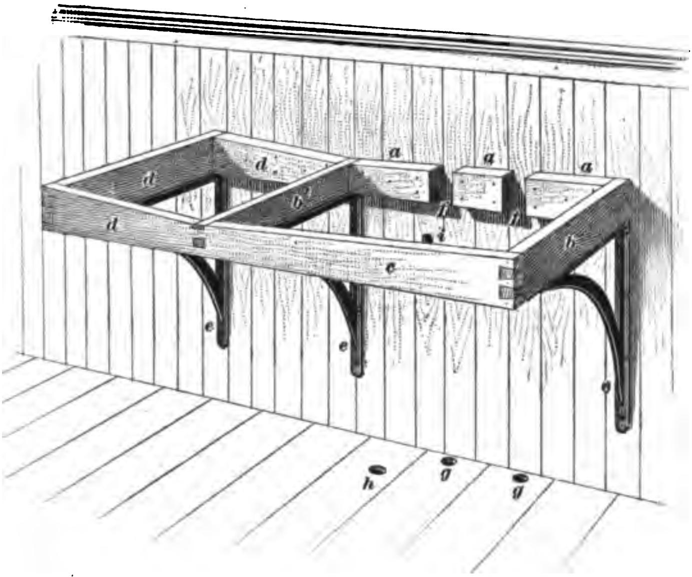

FIG. 4

sink frame. The spaces *f*, *f* and the holes *g*, *g* are for the hot- and cold-water supply pipes, if they come up through the floor. The hole *h* is for the sink waste pipe; the coupling *i*, which projects through the wainscot about ½ inch, is for a **back vent connection.**

10. The common form of waste connection for a pressed-steel sink is shown in Fig. 5. A brass sleeve *a* passes down through a hole in the sink. A locknut *b*, when screwed up on the threaded end of *a*, squeezes a leather or other gasket against the bottom of the sink and makes a water-tight joint. A brass coupling *c*, shown screwed up, can be unscrewed and the coupling tail *d* soldered to the sink trap. This coupling joint is usually made tight with a leather gasket. The strainer is held in place by a screw *e* screwed into a cross-piece cast in *a*.

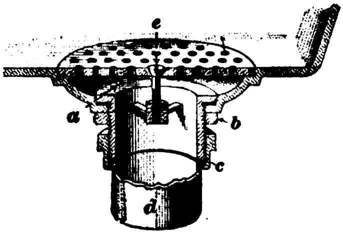

FIG. 5

11. The first cost of a pressed-steel sink is less than that of a cast-iron sink, but the cast-iron one is much more durable, and is cheaper in the end. Iron or steel sinks can be obtained with **porcelain enamel linings**; they are quite reasonable in price and appear well when new, but the enamel cannot withstand very rough usage; it chips off easily. Enameled iron is quite suitable for sinks that are not supplied with hot water, and particularly so for sinks that do not receive rough usage. Iron pans, pails, and cooking pots are frequently scoured in kitchen sinks; their sharp edges easily chip the enamel coating and thus expose the iron, which mars the appearance of the sink.

12. **Cast-Iron Sinks.**—There are sinks in the market made of cast iron. These are made generally as shown in Fig. 3, that is, with a flat-flanged, square-cornered top about 1 inch wide, square or rounded inside corners, sloping sides, and a slightly sloping bottom, the strainer opening being from ¼ inch to ½ inch deeper than the opposite end. They are usually made with **lugs** or **sockets** on the side to receive the top of sink legs, as shown in Fig. 6 (*a*). A section on the line *b b* is shown in Fig. 6 (*b*). The sockets are slightly wider at the bottom than at the top, and the top of the sink leg *c* is tapered to fit the socket. This makes a strong sink support, and is preferable to brackets; it is especially recommended for common cast-iron sinks.

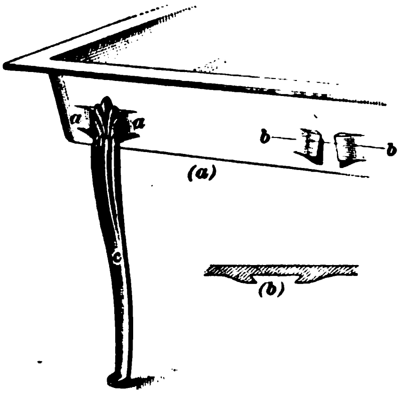

FIG. 6

13. The **strainer connection** to a cast-iron sink is usually made as shown in Fig. 7. The lead waste pipe *a* is flanged over the conical nozzle *b* of the sink, and is held in place by the clamp ring *c* and the bolts *d*, *d*. To prevent water from leaking past the heads of the bolts and trickling down on the outside of the pipe, washers of rubber or leather are set up tight by the nuts *e*, *e*. This strainer waste connection is usually employed for kitchen sinks, because it is

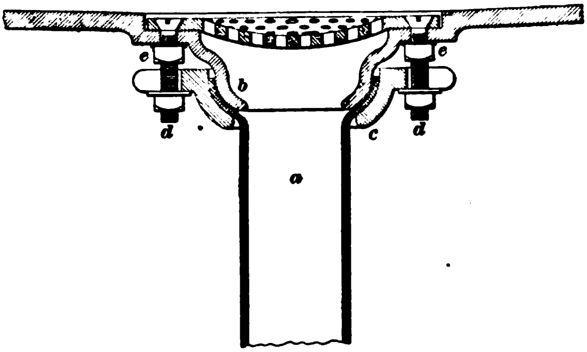

FIG. 7

customary among cooks and scullery maids, or dishwashers, to use portable tin dish pans for washing dishes, the sinks being used only as receptacles to receive, and drain away as quickly as possible, the water poured into them.

14. Should it be necessary to arrange a sink to hold water, a **plug sink strainer,** shown in Fig. 8, may be used instead of the plain perforated strainer shown in Fig. 7. The strainer is made of brass, and the plug may either be of brass ground to fit the socket, or of rubber. The flange should be bedded down with putty made of red and white lead in order to be water-tight.

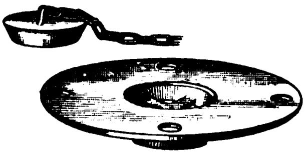

FIG. 8

15. The clamp ring *c* in Fig. 7, also called **sink coupling,** or **sink ring,** is intended for a lead-pipe connection. Should it be desired to connect the sink to iron pipe, a heavy **screwed sink coupling,** shown in Fig. 9, should be used. This is tapped 1½ inches or 2 inches to suit the size of waste pipe required.

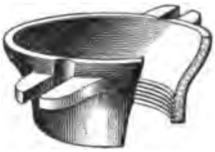

FIG. 9

16. Cast-iron kitchen sinks can be purchased from plumbers' supply houses either plain, painted, galvanized, or enameled, and with plain flat rims or roll rims. Fig. 3 shows a **plain flat-rim sink,** so called because the rim is flat and plain. This form of rim is usually surmounted by a wood cap, as shown in Fig. 10. The cap *a*, preferably made of ash 1¼ or 1½ inches thick, is bedded down with red-lead putty *b* and is held in place by 2½- or 3-inch brass screws, as shown. This arrangement, however, has too much woodwork, which should be avoided.

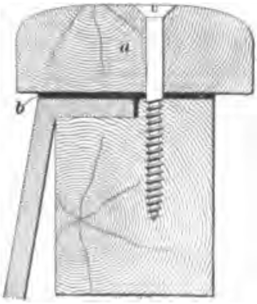

FIG. 10

17. The fixture shown in Fig. 11 is a plain cast-iron sink with a cast-iron **sink back,** which is secured against the wall. This back piece acts as a splash plate, and helps to protect the wall. Here it may be mentioned that sink backs are only necessary when the walls against which the sinks are set are made of porous materials, as plaster or wooden wainscoting, which will rot. If the walls are tiled or wainscoted with marble or other such material, the sink back may be omitted. The sink is supported behind by strips of wood nailed to the studs, as at *a*, *a*, *a* in Fig. 4; the feet of the cast-iron legs are screwed to the floor. The hot- and cold-water pipes run up at the back of the splash plate, which makes a plain, neat finish.

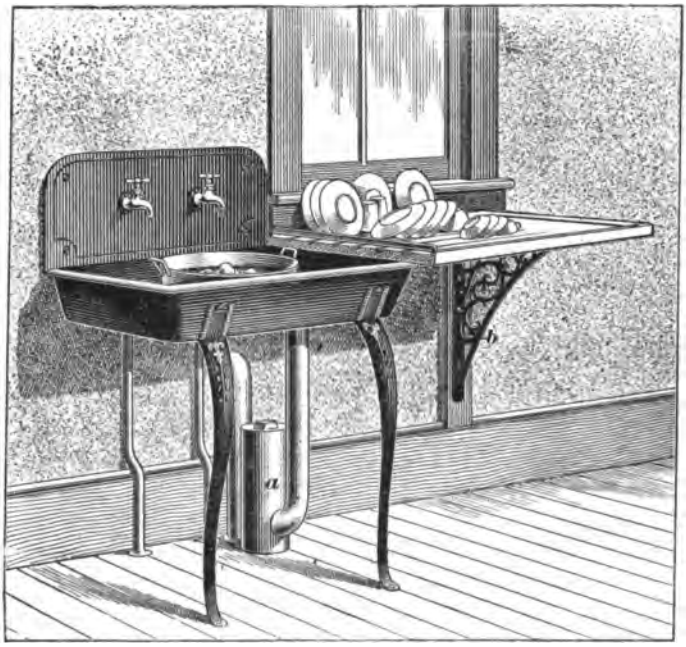

FIG. 11

A simple trap *a* is set on the floor The drain board is fluted with a series of $\frac{3}{8}$-inch grooves cut quite closely together. These grooves all run toward the sink, and drain the drippings from the newly washed dishes into it. The window sill is about 4 inches higher than the drain board, which makes a good support for the dishes to rest against when standing on edge to drain, as shown in the figure. The grooves in the drain board prevent the lower edges of the dishes from sliding out, and the strip across the lower end prevents them from rolling into the sink. The drain board is shown supported at the high end by a bracket *b*, which is quite proper if the bracket is heavy enough. This shelf should be strong enough to safely support a load of 300 pounds, and the joints should all be made perfectly water-tight by being fitted close and bedded in red or white lead. The drain board should be made of well-seasoned ash about 1¼ inches thick. The lower end should be bedded on the sink rim with red lead, and securely held down to the iron with not less than four 1¼-inch brass screws, which are screwed up into the board from the under side of the sink rim.

18. Cast-Iron Enameled Sinks.—A cast-iron, **roll-rim, enameled kitchen sink** of a simple, substantial, and sanitary design is shown in Fig. 12 (*a*). It is furnished with a back 12 or 15 inches high, which has a quarter-round edge, as shown in Fig. 12 (*b*). The roll rim of the sink is half round, as shown in Fig. 12 (*c*). The back plate rests on the sink with a lap joint, made either as shown in Fig. 12 (*d*) or (*e*). The under side of the sink has two circular sockets about ½ inch deep, into which the upper ends of the legs fit, as shown in Fig. 12 (*f*). To prevent the feet shifting on the floor, each has a prong at the bottom of the ball, which is let into the floor about ½ inch, as shown in Fig. 12 (*g*). If the back flange of the sink is flat, it may be supported on wooden cleats, or better still, on angle irons, and fastened by screws or bolts. A simple attachment for supporting the back is shown in Fig. 12 (*h*). The back flange has a vertical flange that can be fastened to the wall. If the space at the back of the splash plate *a* is filled with plaster of Paris, and the screws *b*, *b*, *b*, *b* are properly screwed up, so that the plate *a* cannot shift, this sink will be vermin-proof and thoroughly sanitary in every respect.

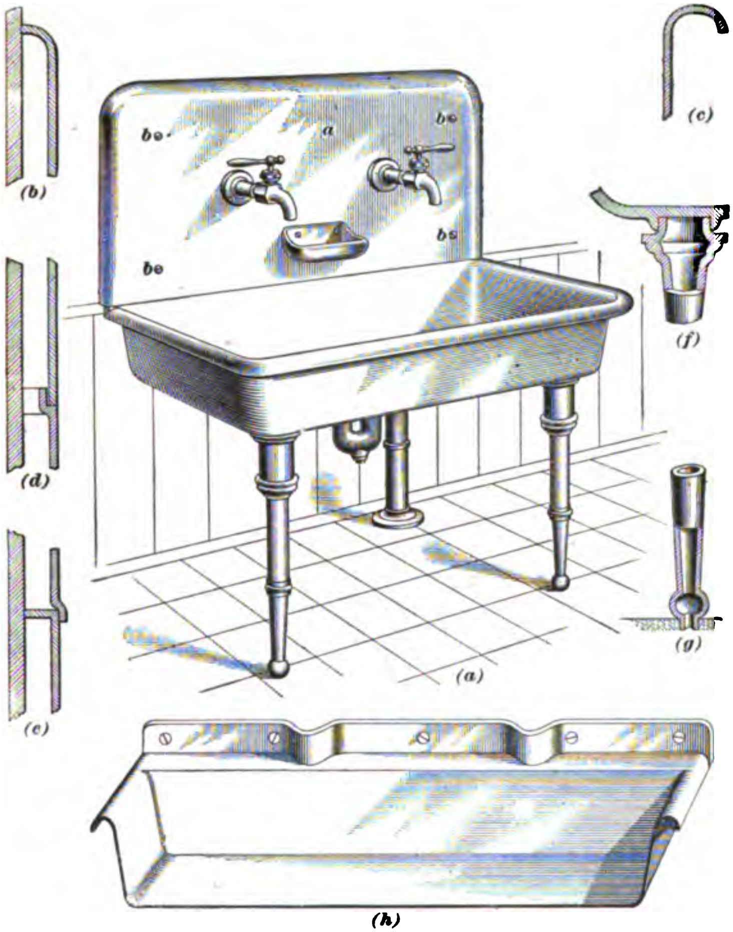

FIG. 12

19. The dimensions of the ordinary sizes of cast-iron sinks are given in Table I, where the length and width are outside measurements, while the depth is measured inside.

TABLE I

CAST-IRON KITCHEN SINKS

Length Inches	Width Inches	Depth Inches	Length Inches	Width Inches	Depth Inches
16½	12½	5	30	20	6
18	12	6	32½	18	6
16	16	6	32½	21	6
22	14	6	36	18	6
23	15	6	36	21½	6
25½	15½	6	38	20	6
20	12½	6	42	22	6
20	14	6	48	20	6
24	14	6	48	23	6
24½	16	6	24	14	8
24	18	6	30	24	8
25½	17½	6	50	24	6½
27	15	6	50	26	6½
24	20	6	62	22	8
28	17	6	76	22	7
28	20	6	56	32	9
30	16	6	60	28	10
30	18	6	78	28	10

20. Solid-Porcelain Sinks.—Fig. 13 shows a **solid-porcelain roll-rim sink** with two drain boards *a* and *b* fitted up complete in a corner. It has a roll rim in front and at the ends. The back, through which the faucets protrude, is also made of solid porcelain, and is bedded down with white-lead putty on the flat rim of the sink. The back is set against the wall in plaster of Paris, and is held in place by the flanges of the sink faucets. The sink is supported by a wrought-iron frame, the back of which is fastened by screws or bolts to the wall, and whose front is supported upon the legs, which are offset to give ample room for the feet of the user. The base of each leg has a ½-inch pin projecting about ½ inch; this is let into the floor to prevent the leg from shifting. Instead of iron or brass legs solid-porcelain legs can be used. They are easier to clean and in this respect are desirable. Porcelain sinks are 2 inches thick, glazed both inside and outside, and made in one piece, which dispenses with the joints so objectionable in soapstone or slate sinks.

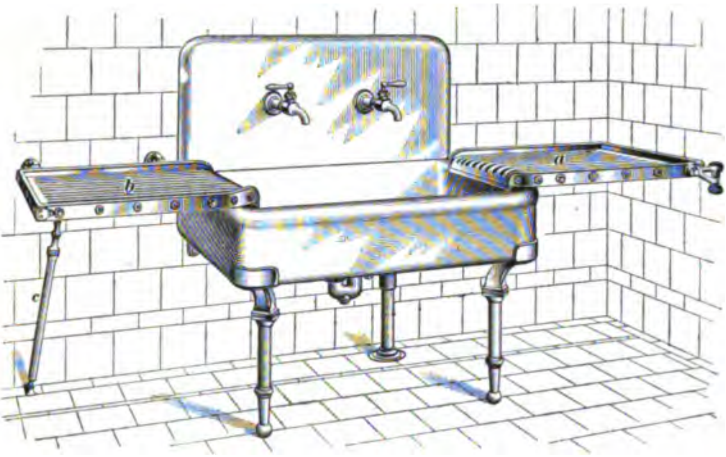

FIG. 13

21. The drain boards shown in Fig. 13 are especially devised for roll-rim sinks and fulfil all practical and sanitary requirements. One end of each is supported by the sink, and the other by brass brackets; otherwise they are entirely free from the wall. The corner drain board *a* swings upwards on the hinges at the right. The end drain board *b* swings on hinges at the back; the supporting leg or bracket *c* is telescopic and lengthens as the board is raised. Automatic catches should be attached to the wall to hold up the boards when they are raised. The boards can be swung up out of the way to allow cleaning around the sink or walls. The boards are made of selected ash, the pieces being tongued and grooved together. Brass rods are run through them to insure non-warping. The rim along the three edges of the board prevents dishes from falling off and water dripping to the floor. The part of each board coming in contact with the roll rim is supplied with a row of rubber fenders to prevent the roll rim from being damaged by the boards falling. Where the board drains into the sink an additional projecting nickel-plated nosing is affixed.

22. The sink arrangement shown in Fig. 13 is thoroughly sanitary, particularly so when the walls and floor are made impervious by using tiles, as shown, or some other non-absorbent material. Sinks of this kind, especially those with porcelain legs, are recommended for the finest class of work.

23. Fig. 14 shows a **recessed standing waste sink** that is intended to be used without a back plate. The recess *a*, which contains a **standing waste** *b*, is set against the back wall. The hot and cold supply pipes may come up one on each side of the recess. This and all other earthernware and porcelain sinks should be set solidly on an iron frame, and supported in front by metal or porcelain legs. All experts agree that sinks intended to be filled with water should be fitted with a standing waste, which positively prevents overflowing.

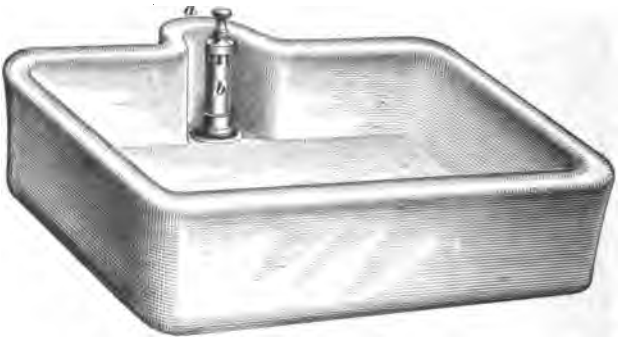

FIG. 14

24. The common sizes of porcelain sinks are given in Table II.

TABLE II

DIMENSIONS OF PORCELAIN SINKS

Length Inches	Width Inches	Depth Inches
28	18	9
30	20	9
36	23	7
42	24	7
48	24	7

25. Slate Sinks.—Some sinks in the market are composed of **slate slabs** or slabs of other materials joined together; such sinks are undesirable because grease and filth collect in the sharp corners, whence it cannot be cleaned out. This matter decomposes and emits offensive odors. Besides, slate is more or less porous, and its pores become clogged with filth.

26. Soapstone and Cement Sinks.—Sinks made from **soapstone** and **cement** are porous and hence should be avoided, even though they have rounded inside corners. These sinks are simply put on the market as a cheap substitute for glazed earthenware, porcelain, or other vitreous goods.

27. Earthenware Sinks.—A special clay is used in the manufacture of **earthenware sinks,** which are molded to the required form. The clay may be burned to vitrifaction, and thus made impervious throughout its thickness; or it may be burned porous like ordinary firebrick, and either **salt glazed** or **enameled** on the surface. A cheap quality is known to the trade as **brown glazed earthenware,** which makes a good, plain, durable sink, but owing to its color, filth cannot easily be seen on its surface. A better earthenware sink is that which is enameled in white on the inside and glazed brown outside; but the best grade of the earthenware class is enameled white all over and appears like a solid-porcelain sink. Earthenware sinks, like porcelain sinks, can be had with plain or roll rims, and in different styles.

BUTLER'S PANTRY SINKS

28. Copper Pantry Sinks.—Sinks intended for butler's pantries are made of various shapes and materials. The most common are made of sheet copper tinned on the inside. They are either struck up from one piece of sheet copper or are built of two or more pieces.

An **oval copper pantry sink** *a*, composed of one piece of sheet copper, is shown in Fig. 15. It is oval in plan and semioval in section. It is supported by a flange *b*, which is nailed down to the board or frame *c* before the hard-wood top *d* is bedded down and secured in position. This form of pantry sink is always provided with an overflow horn, as shown at *e*, and a plug-and-socket waste connection in the center of the bottom, as at *f*.

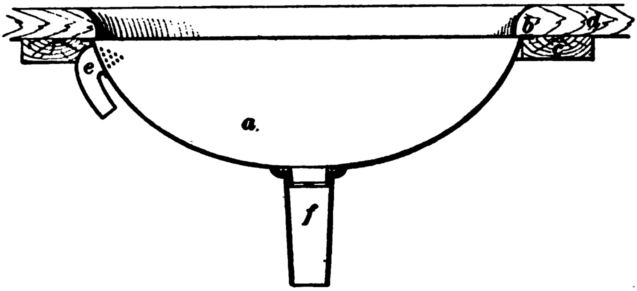

FIG. 15

29. A **flat-bottomed copper pantry sink** is built from flat pieces of tinned sheet copper. Its seams are locked and sweated with soft solder. The bottom is flat, and the sides are usually slightly rounded at the corners. It is also furnished with a flange *a*, Fig. 16, around the top, and nailed to a wooden frame *b*, in order to stiffen the sides and preserve the shape and position of the sink. The hard-wood top *c* is bedded on the frame *b* with red- or white-lead putty and secured with brass screws. The bottom of this sink should be supported by a shelf *d*, which is scooped out in the center, as shown, so that the bottom may be perfectly drained.

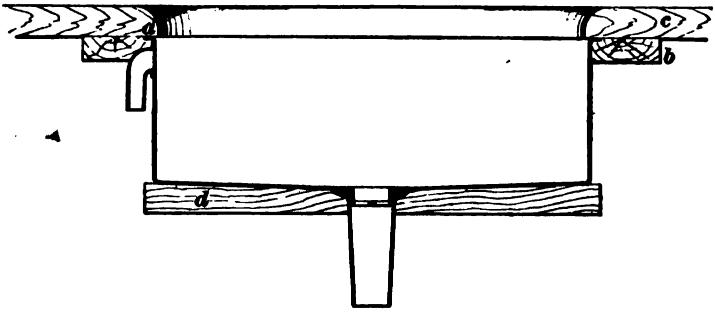

FIG. 16

30. Either galvanized-iron or lead pipe is generally used for the hot- and cold-water supply connections to copper pantry sinks, while the waste pipe, vent pipe, and trap are usually made of lead. Waste and overflow horns made of copper should be connected to their respective pipes by means of soldered joints; there is no objection, however, to the use of cup joints. On the best class of work, the waste horn is wiped to the trap. The pipe from the overflow horn, which is usually 1¼ inches, should join the trap on the house or sink side of the water seal.

31. The usual dimensions of copper pantry sinks are given in Table III.

32. Glazed Earthenware and Porcelain Pantry Sinks. Sinks for pantries made of glazed earthenware and also of porcelain can be obtained. They are made in various styles to suit different tastes and requirements. Fig. 17 shows a popular and thoroughly sanitary arrangement. The sink is made with a recess *a* in the back, which affords room for a standing overflow *b*. This overflow tube is removable from the socket, and serves as a plug that can be pulled up to let out the water. The waste connection is made tight with a locknut and washer under the sink. The trap is joined to the waste connection with a ring coupling.

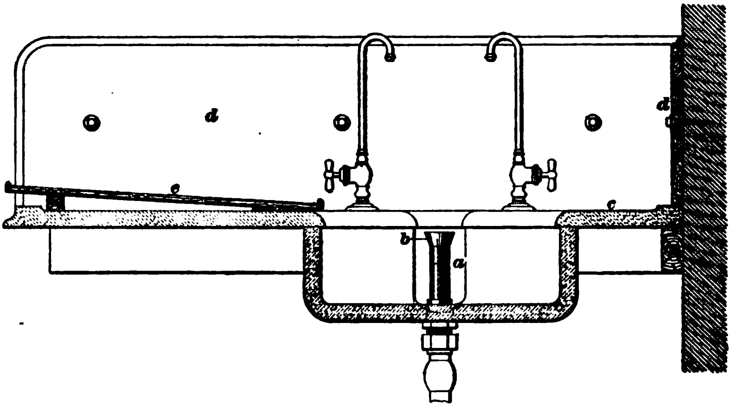

FIG. 17

Earthenware and porcelain sinks are usually fitted with a marble slab *c* and marble splash or wall plates *d*, *d*. A dish drainer *e*, made of wooden slats, or rubber, is used to protect crystal or china dishes from contact with the slab, and thus prevent their being broken.

TABLE III

DIMENSIONS OF COPPER PANTRY SINKS

Length Inches	Width Inches	Depth Inches
12	18	5 to 6
12	20	5 to 6
14	16	5 to 6
14	20	5 to 6
14	24	5 to 6
16	24	5 to 6
16	30	5 to 6
18	30	5 to 6

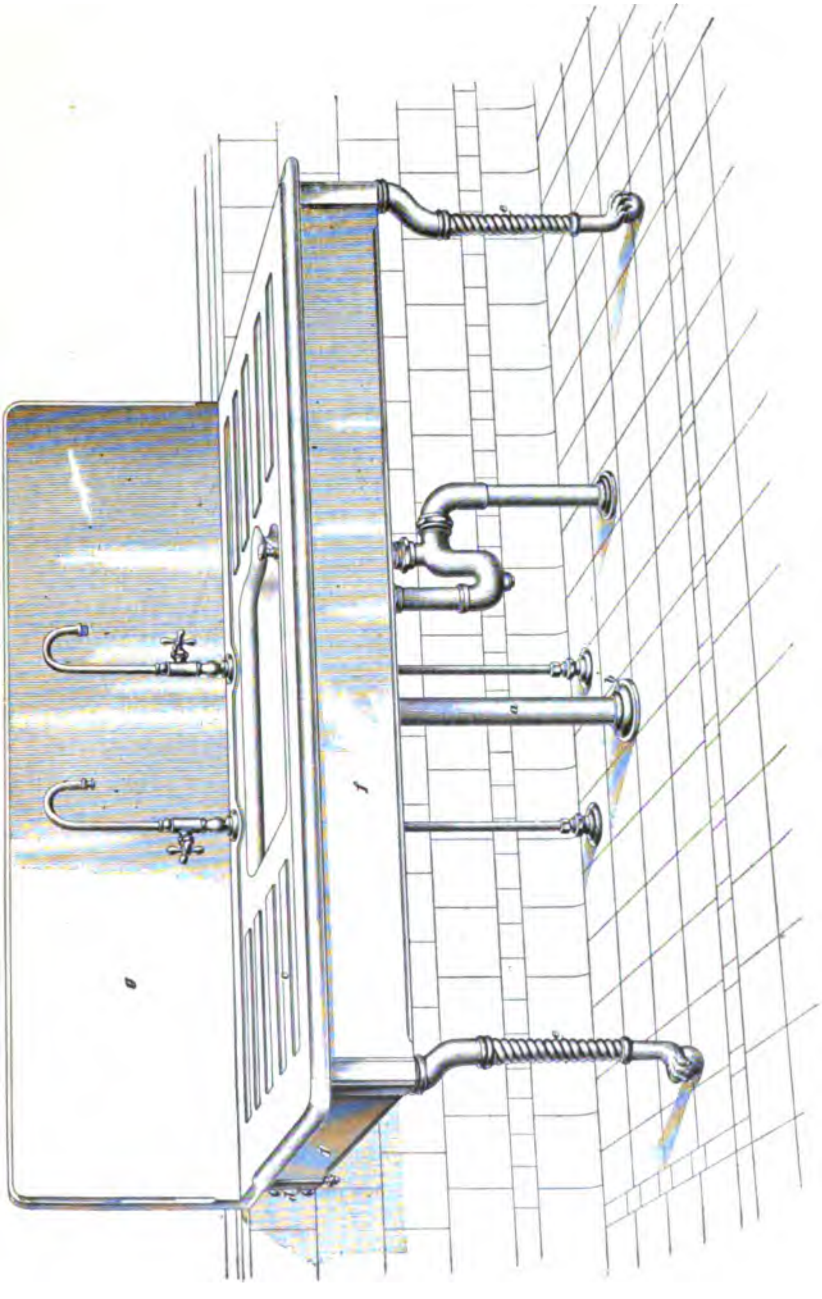

FIG. 18

33. Fig. 18 shows an excellent pantry sink of the most approved class. The sink is made of solid porcelain 2 inches thick, and is recessed at the right-hand end for a standing waste plug-and-socket attachment that allows the sink to be filled with water when desired. The sink is supported by a 2-inch pipe post *a* placed directly under its center of gravity. An iron shelf or crowfoot support *x*, Fig. 19, is screwed to the top of the post to form a solid bed for the sink; the base of the post has a floor flange *b*, Fig. 18, which can be bolted to the floor. The hot- and cold-water pipes come up at the back of the sink. The top, or **sink slab,** *c* is Italian marble and countersunk. The countersinking is so arranged as to drain water back into the sink. The slab has ogee curved edges in front and at the ends, and should be 1¼ inches or 1½ inches thick. It is supported at each end by a nickel-plated brass bracket or **apron holder** *d*, Figs. 18 and 20, fastened to the wall, and two nickel-plated brass legs *e*, *e*, Fig. 18, in front. Marble aprons *f*, *f*, 7 inches deep, and between the points of support, ¾ to 1 inch thick, reenforce the marble slab and give the sink a solid, neat appearance. The aprons are held in position, at the corners, by the legs, the tops of which are recessed to receive them, as shown at *h* in Fig. 21. The dowels *i*, Fig. 20, and *j*, Fig. 21, are let into the slab. The dowel *i* prevents the slab from working away from the wall, and *j* prevents the leg from falling forwards. The slab is usually bedded on the sink with plaster of Paris. Some plumbers, however, seem to think that a more waterproof job is accomplished by first painting the under side of the slab, just over the sink, with shellac varnish, and then

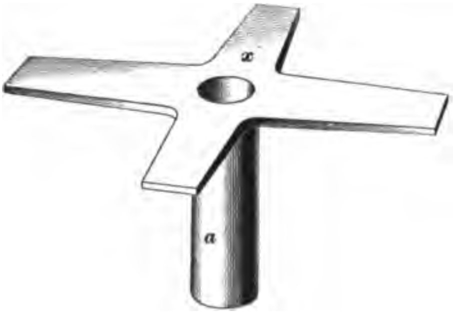

FIG. 19

bedding the slab on the sink with a cement composed of shellac and powdered white lead. The back, or splash plate, *g* is 18 inches high and from $\frac{7}{8}$ to 1 inch thick. All the marble should be polished and made impervious to water on its exposed surface. The back may be secured to the wall with plaster of Paris, but if there is danger of vibration, it should be additionally secured with three or four nickel-plated, round-headed screws and washers.

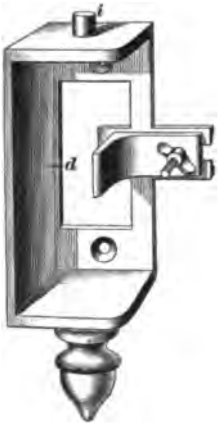

FIG. 20

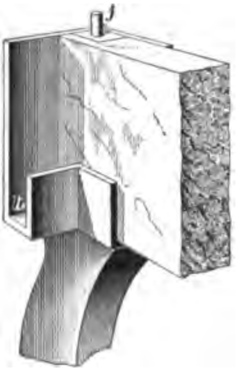

FIG. 21

To prevent splashings of water from saturating the surroundings of the sink, it is advisable to tile the walls and floors as shown, so that they may be non-absorbent and easily cleaned.

FIG. 22

34. To lessen the risk of glass and chinaware being broken while being handled on porcelain, marble, or other hard-substance sinks, it is advisable to provide a wooden or rubber **sink mat,** which may be laid on the bottom of the sink or placed on the top.

Fig. 22 shows a good wooden mat very suitable for a kitchen or pantry sink. It is made of hard-wood slats held together by brass rods and will effectually prevent the scratching and discoloring of the sink when pots, etc. are handled thereon. These mats are somewhat flexible and therefore not very liable to chip the sinks should they slip and fall in.

35. The common sizes of earthenware pantry sinks are given in the following table:

TABLE IV

DIMENSIONS OF EARTHENWARE SINKS

Length Inches	Width Inches	Depth Inches
20	14	4½
23	16	5½
25	17	5½

SLOP SINKS

36. Purpose.—A special form of sink is used for the purpose of receiving slops, chiefly from bedrooms, and is called a **slop sink.** It differs from a kitchen sink chiefly in dimensions, being shorter and narrower, but deeper. A slop sink is usually set so that its rim is about 20 inches above the floor.

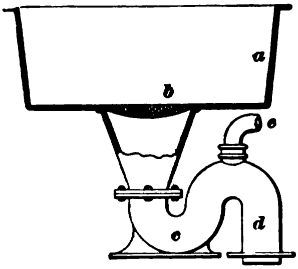

FIG. 23

37. Cast-Iron Slop Sinks.—In Fig. 23 is shown a form of slop sink known to the trade as a **slop hopper sink.** The sink bowl *a* is provided with a strainer *b* that can be removed to clean the trap *c* below. It is supported directly upon *c*, which is a 4-inch trap. The outlet end *d* of the trap is flanged so that it may be attached to a lead waste pipe. The trap may be had without this flange; it is then calked into the socket of an iron pipe. A 2-inch back-vent connection *e* is made to the trap. This fixture, which is cast iron, is shown with a plain rim, but can be obtained with a roll rim.

38. Fig. 24 shows a modern **enameled-iron roll-rim slop sink** *a* supported by a flange bolted to the trap *b*. The sink is set a few inches clear of the back wall, and the hot- and cold-water supply pipes come up at the back of the sink.

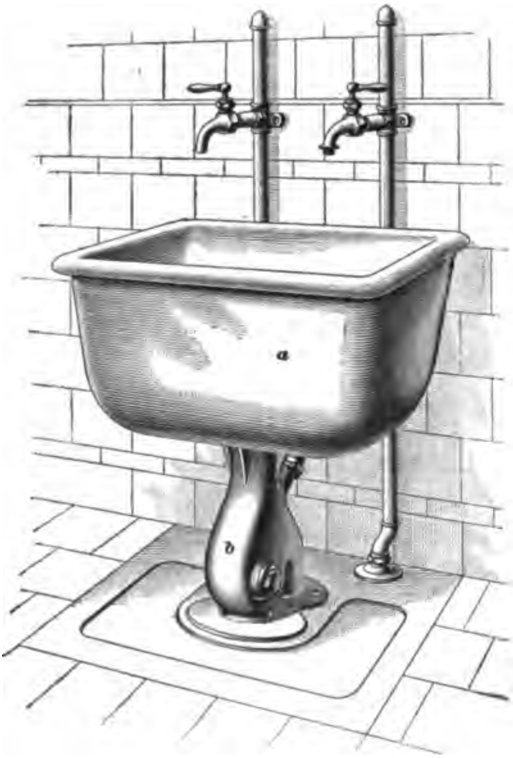

FIG. 24

The faucets are attached at a height of about 10 or 12 inches above the roll rim.

39. The usual dimensions of cast-iron slop sinks are given in the following table:

TABLE V

DIMENSIONS OF CAST-IRON SLOP SINKS

Length Inches	Breadth Inches	Depth Inches
16	16	10
20	14	12
20	16	12
24	20	12
30	20	12
36	18	12
36	21	12
23	15	15
36	21	16
48	20	12
48	20	17
60	20	12

40. Porcelain Slop Sinks.—Fig. 25 shows a **solid roll-rim porcelain slop sink** with a nickel-plated hinged brass guard *a* over the front rim; this guard protects the rim against rough usage from pails, etc. This sink is cleaned only by water from the faucets and hand labor.

41. Slop sinks that receive chamber slops and sewage matter are usually provided with flushing rims and flush tanks, and are cleansed in a manner similar to water closets. They are constructed with large traps, and are connected to the drain pipes in a manner similar to the connections of water closets. Slop sinks are often supplied with hot- and cold-water faucets similar to those used for sinks, and thus do service as housemaids' or chambermaids' sinks. They should be set in a well-lighted and well-ventilated closet, or other small apartment, convenient to the bedrooms.

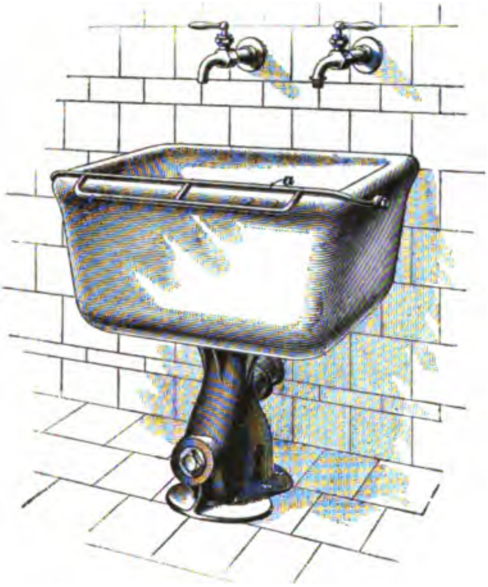

FIG. 25

42. A **porcelain flushing-rim slop sink** of highly approved make is shown in Fig. 26. This fixture is well adapted for use in hotels, dwellings, etc. It is a solid-porcelain sink having a bronzed cast-iron trap serving as a standard; a cherry, ash, or oak copper-lined flushing tank *a* overhead; a nickel-plated brass flush pipe *b*; nickel-plated brackets under tank; a nickel-plated guide rod *c*; a porcelain pull *d*; a nickel-plated combination faucet *e*; and hot and cold supply pipes *f* and *g*. A slight touch of the pull *d* causes water to fall from the tank and cleanse the inner surface of the sink. The roll rim *h* of the sink is hollow and forms a flushing rim that distributes the water from the tank all over the inner surface of the sink and gives it a good flushing effect. The flushing rim is molded in one piece with the sink.

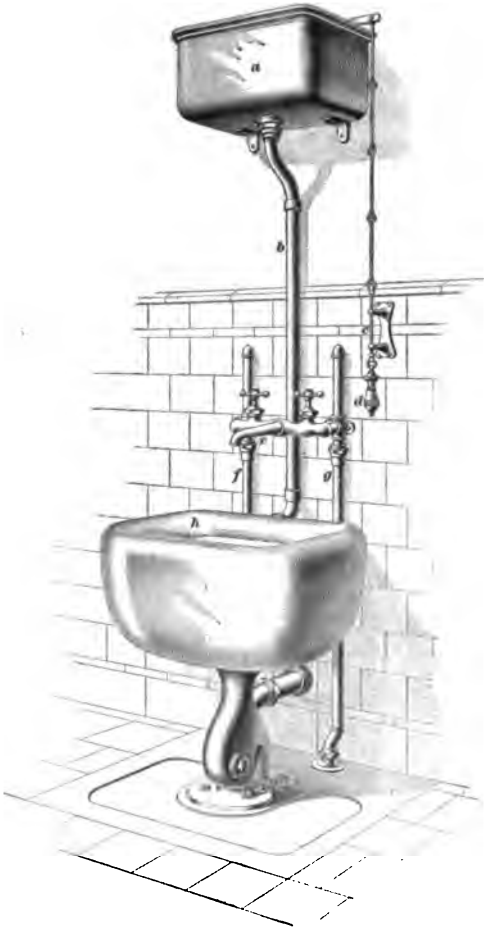

FIG. 26

If a flushing-rim slop sink is to be subjected to very rough treatment, it is advisable to mount it with a special nickel-plated brass rim that will also act as a flushing rim. The trap being set on a broad base, and strongly secured to the sink by the strainer, forms the only support for the sink. It is back vented with a 2-inch pipe.

43. Good flushing-rim slop sinks may be fitted with faucets like a kitchen sink and flushed through them instead of through a flushing tank, but the flushing-tank arrangement, shown in Fig. 26, is recommended for high-class work. The most popular size of the style of sink shown in Fig. 26 is about 20 inches long by 20 inches wide and 11 inches deep, but other sizes are on the market, as shown in the following table:

TABLE VI

DIMENSIONS OF PORCELAIN SLOP SINKS

Length Inches	Width Inches	Depth Inches
20	16	12
20	20	11
22	18	12
24	20	12

WASH SINKS

44. Long Troughs.—A class of sink that is specially adapted for use in mills, factories, and other places where a large number of people are liable to use it at the same time is known from its form as a **long-trough wash sink.** As implied by the name, it is simply a long trough supplied with cold water and occasionally with hot water, from a number of faucets. Such a sink should be enameled inside and have a roll rim.

45. Fig. 27 shows a form of wash sink that is used in many industrial establishments. It is composed of a number of sections *a'*, *a*, *a*, with flanged ends that are bolted together, red-lead putty being used between the faces of the flanges to make the joints water-tight. The water pipe *b* runs between the troughs and supplies them through faucets placed about 2 feet 6 inches apart. The space between the troughs is from 2 to 3 inches wide, and is closed on top by an enameled cast-iron cap *c*. The trough is supported on cast-iron standards *d* that are screwed to the floor. The sections *a'*, *a'* are the middle sections of the double trough,

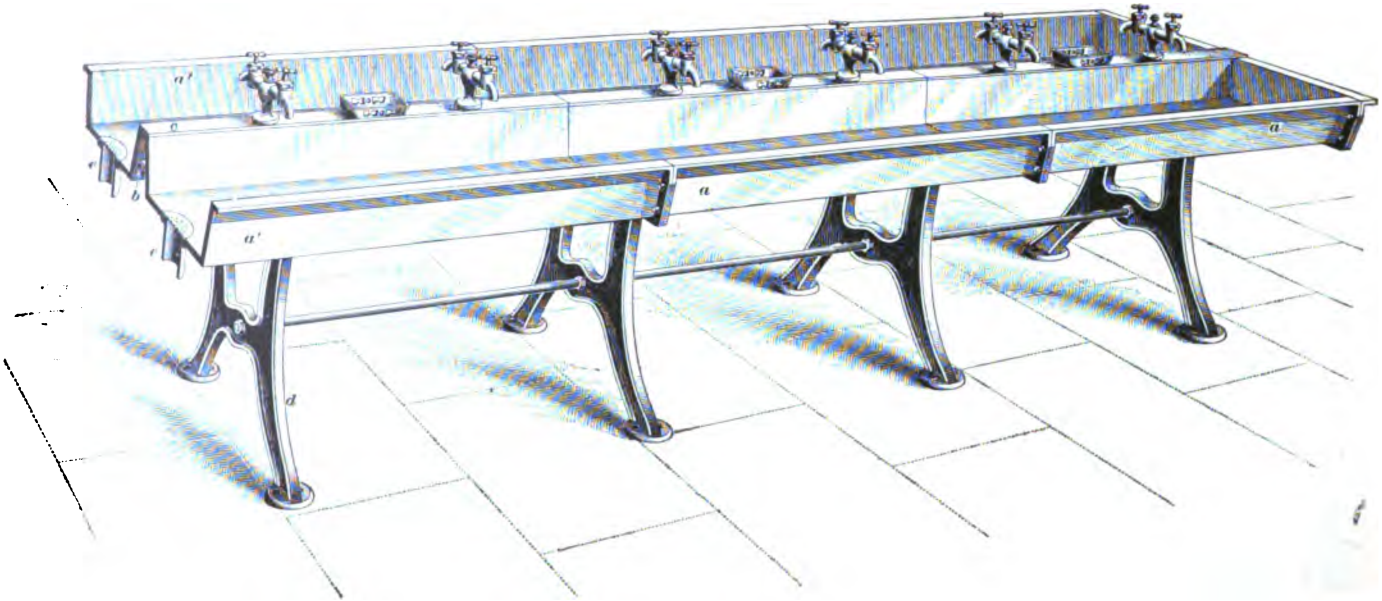

FIG. 27

and each middle section is furnished with a waste connection *e*, *e* having a strainer. Sometimes a plug-and-socket waste outlet is used. The bottom of the trough has a pitch from the ends to the outlet.

Any length of trough can be obtained by inserting sections, but in ordering these wash sinks the exact length should be given, so that the manufacturer can ship sections of the proper depth and pitch.

46. The capacity of wash sinks is proportioned to the number of people who will use them at the same time. To avoid excessive loss of time by people awaiting their turn, it is considered good practice to allow 30 inches of length of trough and one faucet for every six or eight people who are supposed to use them.

47. The sinks shown in Fig. 27 stand back to back and are set in the middle of the wash-room floor. If it is desired to arrange them against the wall, a cast-iron enameled back plate is placed at the back of each section, and the faucets are attached to pipes coming through the back plate.

The width of wash sinks is generally 18 inches; the depth of the middle section is 8 inches; the depth of the end section is 5 inches. The greatest length that can be obtained without necessitating a change of the manufacturers' patterns is about 55 feet.

LAUNDRY TUBS

WOODEN LAUNDRY TUBS

48. Construction.— The tubs used in laundries for washing clothes, etc. are known as **wash tubs, laundry tubs,** or **trays** in different localities. The cheapest varieties are made of wood, the ends and partitions being rabbeted into the sides and bottom. The joints should be well painted with white lead, and should be drawn tight by means of iron bolts. Repeated drying and wetting soon spoils the joints and rots the wood. When they become leaky past repairing, they may be lined with tinned copper, galvanized iron, or zinc.

49. Disadvantages.—Wooden tubs are very unsanitary. They are out of date and should never be installed for laundry purposes, chiefly because of their tendency to absorb organic matter, which decomposes in the pores of the wood, and emits disagreeable, if not dangerous, odors. It is advisable to replace them, where possible, with sanitary fixtures.

CAST-IRON LAUNDRY TUBS

50. Cast-iron tubs, either galvanized or porcelain enameled, are cleanly, durable, and generally satisfactory. The corners are all rounded, and no crevices exist in which dirt may accumulate or which will harbor vermin. The only drawback to enameled tubs is that the enamel will eventually crack and chip off. When the enamel is chipped off and the iron body is consequently exposed, the rust formed by the iron may discolor the water and spoil it for washing purposes. They are therefore not to be recommended for first-class work.

CEMENT LAUNDRY TUBS

51. Tubs made of cement are often used on the cheapest work, and have been found to serve the purpose well when made from the best Portland cement, but they are porous and consequently have the disadvantages of the old wooden tub. The common dimensions of cement tubs are given in Table VII.

TABLE VII

DIMENSIONS OF CEMENT TUBS

Number of Parts	Length Inches	Width Inches	Depth Inches
2	48	21	16
2	48	24	16
2	53	24	16
2	60	24	16
3	72	21	16
3	72	24	16
3	80	24	16
3	90	24	16

PORCELAIN AND EARTHENWARE LAUNDRY TUBS

52. Advantages.—Tubs made of porcelain or brown glazed earthenware are very heavy and require a substantial iron frame to support them. . They are very durable and are easily kept clean. The corners are all rounded off to prevent accumulations of dirt. If finished flat on top, they are usually supplied with wood rims of ash to protect their edges. The rims should be set in red-lead putty before being bolted down tight. Porcelain tubs of the finest grades are usually finished on top with a roll rim; no wood rim is then required.

53. Positions of Faucets.—Laundry tubs are sometimes fitted with wooden covers that are hinged at the back. When these are used, the faucets must be placed within the tubs, the connections being made through holes in the back. This arrangement is objectionable, because the faucets occupy too much of the interior space of the tubs. The fabrics will catch and tear on the nozzles of the faucets, and the laundress is likely to bruise her hands on them.

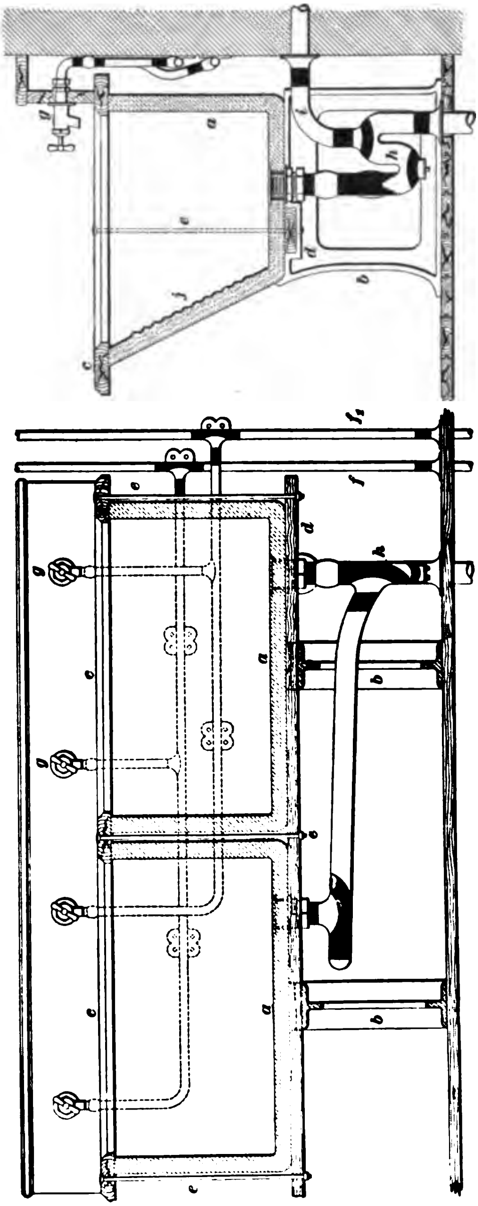

FIG. 38

54. Installation.—Tubs vary in length from 24 to 30 inches, and in depth from 14 to 16 inches. They are usually 22 to 24 inches wide at the top, and taper downward on the front side to 15 inches or more at the bottom. They are generally set up in groups of three. The rim of the tubs should be set about 32 inches above the floor. Each tub should be fitted with an outlet plug and strainer, but an overflow connection is not strictly necessary. In fact, the best tubs on the market are not fitted with overflows. It is necessary only to have overflows on tubs that are set over rooms — such, for example, as on the several floors of apartment houses or flats. Two or three wash tubs may all be connected to one waste pipe. One 2-inch trap is sufficient for three tubs. Each tub should have its own hot- and cold-water faucets. The faucets should, if practicable, be placed above the tubs. In fitting up a set of tubs, provision should be made for attaching a clothes-wringer to the right-hand end of the right-hand tub, with a space of at least 2 feet between this tub and any wall to the right for a clothes basket.

55. In Fig. 28 is shown a set of two porcelain or glazed earthenware wash tubs *a*, *a*. They are set upon two cast-iron stands. An ash frame *c* is bolted to a hardwood strip *d* by long bolts *e*, *e*. Branches are taken from the hot and cold lead water pipes *f*, *f*, to supply the tub cocks *g*, *g*. The waste water from the tubs passes through a lead **S** trap *h*, which is connected as shown. The trap is protected against siphonage by a 1½-inch lead back vent pipe *i*. One of the tubs has part of its inner surface corrugated, as at *j*; this is often used as a scrubbing board.

56. A superior set of modern laundry tubs is shown in Fig. 29. It is composed of three solid-porcelain roll-rim tubs 2 inches thick set on three iron frames, the fronts of which are supported by iron or porcelain legs and the backs by brackets bolted to the wall. The tubs are fitted with porcelain backs through which the hot- and cold-water pipes pass, and are connected to special tub cocks, as shown.

A well-seasoned, brass-bound ash board *a*, called a **wringer base,** is secured by long bolts to the roll rims over each space between the tubs. A wringer base is an excellent feature, since all tubs should have accommodation for a clothes wringer. The waste pipe *b* is a 1½-inch or 2-inch brass pipe, and a 2-inch trap is used. A special feature in the trap shown is its trap screw *c*, the location of which makes access for cleaning-out purposes easy. A trap screw is also placed at the highest point *d* (the right-hand end) of the waste pipe to permit this pipe to be cleared with rods when desired.

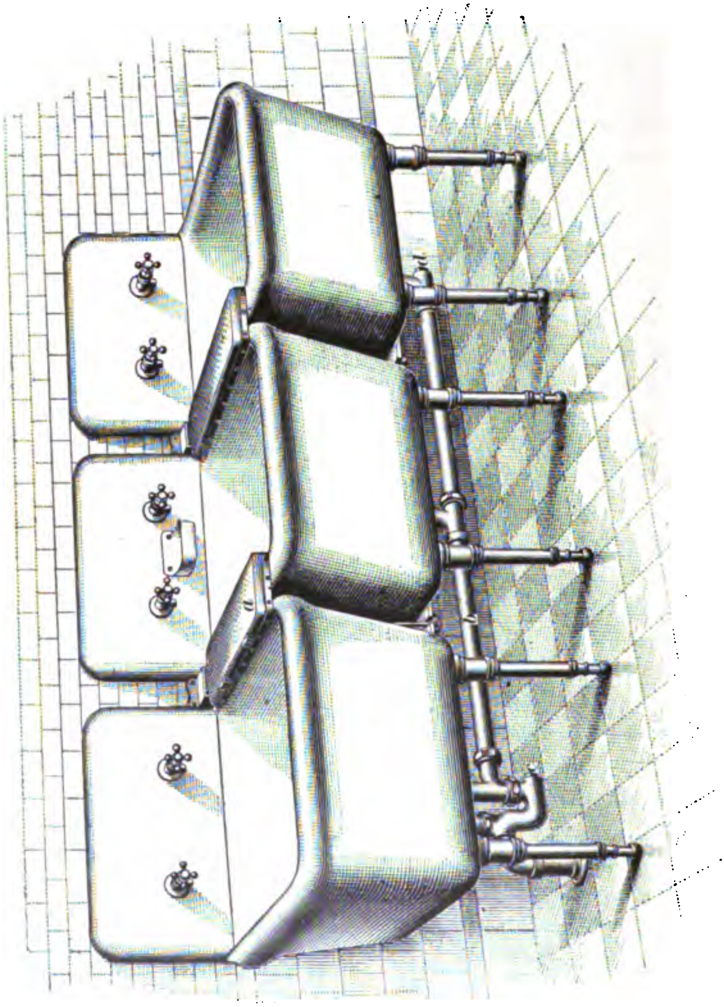

FIG. 29

The arrangement shown in Fig. 29 is especially suitable for a large laundry, and is a thoroughly sanitary fixture in every respect.

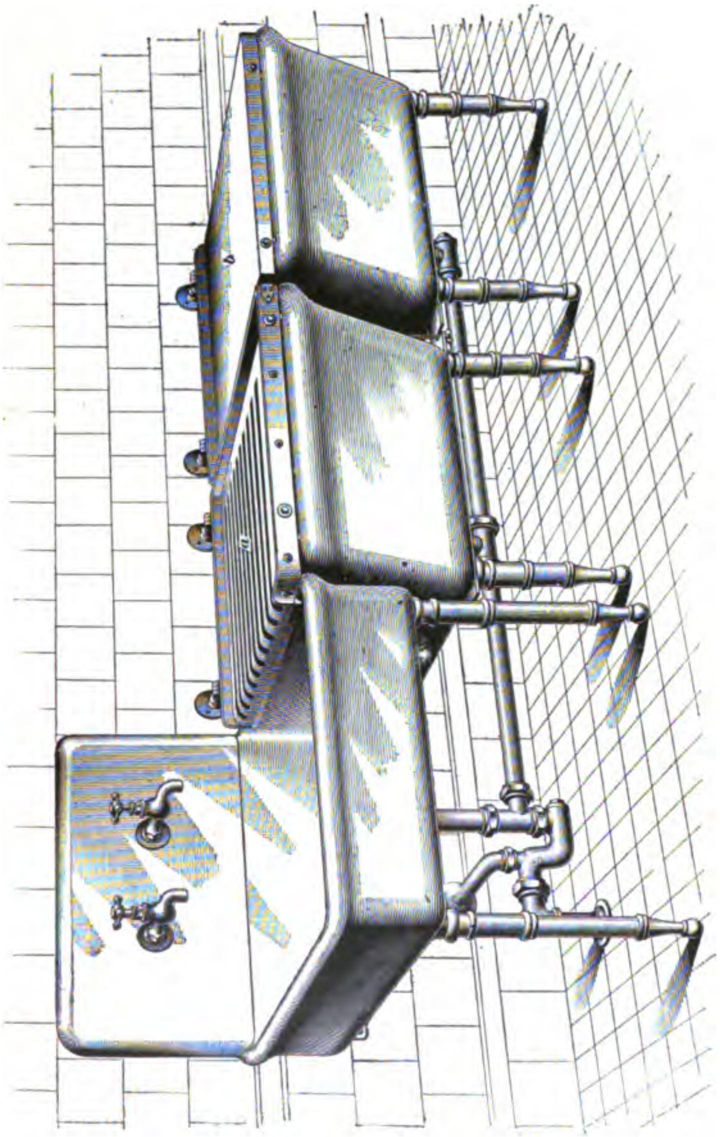

FIG. 30

57. Fig. 30 shows an excellent arrangement of laundry fixtures for buildings without a laundry. The fixtures used are a porcelain sink and two laundry tubs in combination; the arrangement is therefore adapted for use in kitchens of apartment houses, etc., because it economizes space. The combination drain board and cover *a* and the cover *b* can be turned up against the wall when it is desired to use the tubs. A wringer can be used between the tubs if desired, and can be attached easily and quickly by tightening a thumbscrew. In this case the tub cocks are attached to the back of the tubs under the covers.

SOAPSTONE AND SLATE LAUNDRY TUBS

58. Advantages and Disadvantages.—Some tubs are made of soapstone or slate slabs, which are joined by red-lead cement and are held together by rods and iron frames. Inferior soapstone will crack if subjected to hot water. These tubs are liable to permit grease and dirt to accumulate in the sharp corners unless carefully cleaned. This is a bad feature, which, combined with their liability to be porous, makes them unsuitable for use in good buildings. It is common practice, however, to use them in small buildings where the owners cannot afford glazed earthenware or porcelain tubs.

59. Installation.—Fig. 31 shows a set of two soapstone or slate tubs fitted up complete in the cellar of an ordinary small six- or eight-room dwelling. Two tubs are usually enough for such a house. For this class of buildings they must usually be cheap, and the tubs shown are therefore adapted to the work. Each tub is provided with a plug-chain-and-socket attachment for the waste outlet in the bottom. The tubs are supported on three cast-iron stands, one at each end and one in the middle. As these tubs are liable to crack, they should carry a guarantee for at least a year.

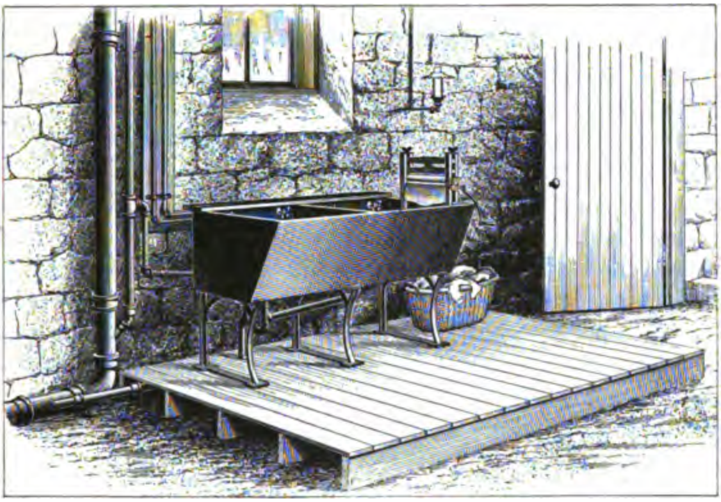

FIG. 81

The pipes and connections show how such tubs may be fitted up to the best advantage.

60. The usual dimensions of slate tubs are given in the following table:

TABLE VIII

DIMENSIONS OF SLATE TUBS

Number of Parts	Length Inches	Width Inches	Depth Inches
1	24	24	16
2	48	21	16
2	54	24	16
3	78	24	16

LAVATORIES

OVAL AND ROUND WASH BASINS

61. Sizes and Materials. — **Wash basins** are either round or oval. The oval basin affords more space for the free use of the arms than a round one of the same capacity, and is, therefore, to be preferred.

Basins are measured over the outside of the top flange. Round basins vary in diameter from 12 to 16 inches. Oval basins are usually made in three sizes, 17 in. × 14 in., 19 in. × 15 in., and 21 in. × 16 in. The term **bowl** is now often used instead of **basin.** Both terms refer only to that part of the fixture which holds the water. The term **lavatory** is commonly used to specify the combination of the basin, its slab, legs, back, aprons, waste, vent, and water-supply connections.

Basins are made of iron, galvanized or enameled, and also of porcelain. The porcelain basins are made in plain white color, or they are decorated to any degree of elegance that may be desired. Wash basins are constructed in many ways. In the most common variety, the bowl is separate from the slab, or top; the splash plate, or back, is also separate from the slab. In other varieties, the bowl, top, and back are made in one piece of metal or porcelain. Wash basins are supported on substantial wall brackets or on metal frames or pedestals. They should never be cased in with cabinetwork, because such enclosures cannot be kept clean and vermin will find lodgment in the crevices of the woodwork.

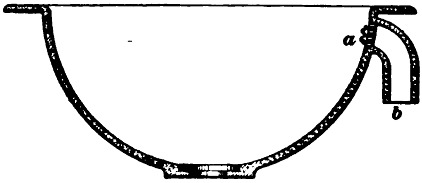

FIG. 32

62. Examples of Wash Basins.—Bowls are made with and without overflows, and the latter are constructed in different ways. In Fig. 32 is shown a common **round bowl**

with overflow horn attached. The overflow consists of a strainer *a* and a nozzle, or horn, *b* to which a waste pipe is attached by a cemented slip joint, or by a rubber cone connection. The latter is preferable, providing the rubber is of good quality.

This form of a bowl necessitates the use of a separate overflow pipe to connect the horn to the waste pipe. In all such connections, the overflow connection must be made to the waste pipe between the basin and the trap, or to the trap itself and under the water. This is an objectionable form of overflow, because it cannot readily be cleaned.

63. In Fig. 33 is shown a **combined bowl and overflow.** The overflow duct *a*, which is molded on the basin, leads into the waste outlet *b* through holes *c* in the connection under the rubber plug *d*. This also is objectionable, because it cannot be easily cleaned.

The connection between the waste pipe and the discharge outlet of the basin is commonly made by means of a plug and socket having a screw coupling, as shown. Great care must be exercised in screwing up this joint, because the bowl is very liable to crack or break at the joint. A thick gasket of soft rubber should be used between the locknut *e* and the porcelain.

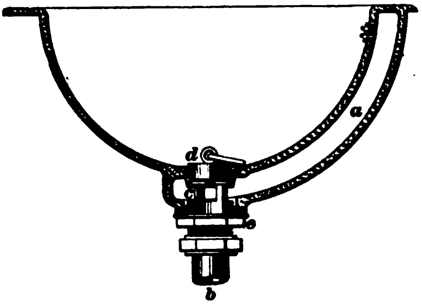

FIG. 33

64. In Fig. 34 is shown a basin with a **standing overflow** inside a recess *a* in the porcelain bowl. The standing overflow *b* also forms a waste plug, and is perforated at its base, as shown, to form a strainer, which can be easily cleaned by lifting out the entire waste plug and overflow arrangement. The top of *b* slides in a guide that is secured

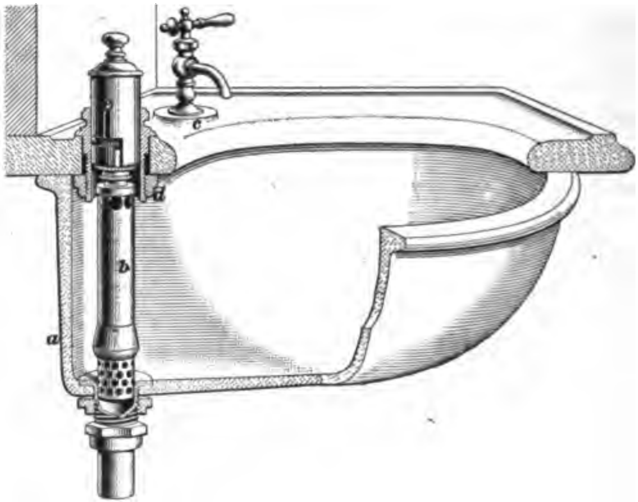

FIG. 34

to the marble top *c* by a locknut *d*. The standing waste is suspended by a bayonet catch, as shown at *e*.

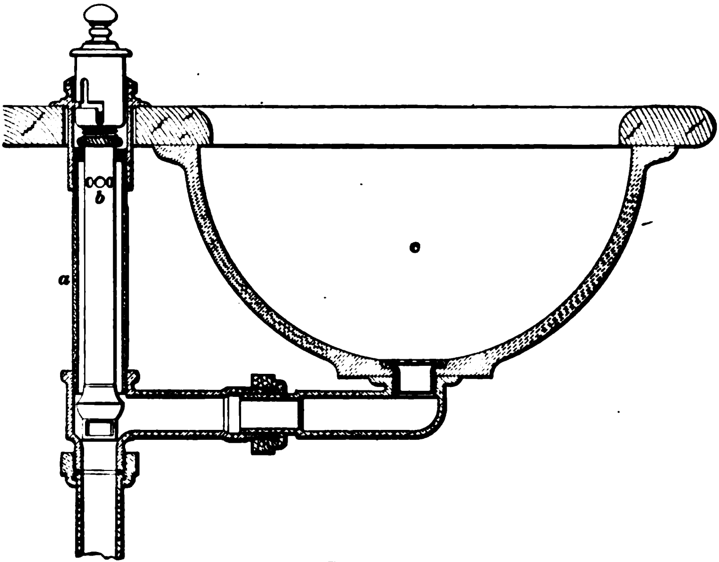

FIG. 35

65. **A combined stand pipe waste and overflow** is shown in Fig. 35. The stopper and standing overflow are contained in the stand pipe *a*. The surplus or overflow water escapes through the holes at *b*. The bowl *c* is made plain, without even a stopper, and has a strainer only.

66. Bowls are also made with *flushing rims*, and the faucets are placed below the top, having only the handles in sight. The rim of the bowl is thus freed from all obstructions, and the hands of the bather cannot be injured by the nozzles of the faucets.

67. Inventors and designers have spent much time and thought in improving wash basins. The overflow, it would appear, has received more consideration than the other parts. This, no doubt, is due to the fact that the old-time overflows on becoming foul cannot be conveniently cleaned, and therefore emit disagreeable odors. From a hygienic standpoint, the changes incorporated in modern basins are excellent.

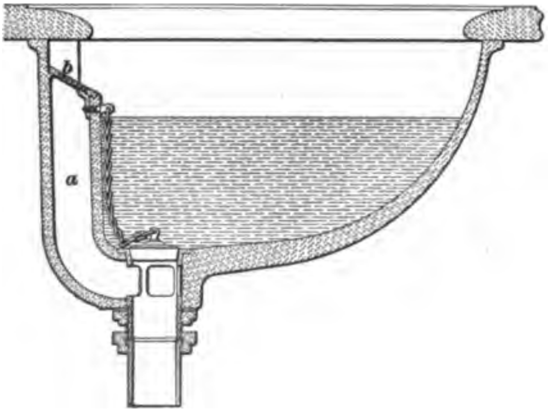

FIG. 36

68. Fig. 36 shows how an overflow *a* is formed at the back of the basin. A strainer *b* lies over the opening and can be lifted off at any time by first unscrewing the chain stay; the overflow can then be conveniently cleaned. Other improvements over the old forms of common basins are the placing of the chain and plug as far back and out of the way as possible, and an extra thick bottom, which makes the basin less liable to break.

The basin shown in Fig. 36 is oval, and is made either 17 in. × 14 in. or 19 in. × 15 in.; this class of basin is in general to be recommended for plain, substantial work.

69. Fig. 37 shows, in section, a heavy, all-porcelain wash basin, especially adapted for use in hospitals, schools, etc. The bowl *a*, top *b*, and aprons *c* are all in one piece, while the back plate *d* is separate. Owing to the fact that marble tops often crack and break, and that the joint between a porcelain basin and a marble top is weak and often leaks water, all-porcelain basins of this class are to be recommended for places where they are liable to receive rough usage.

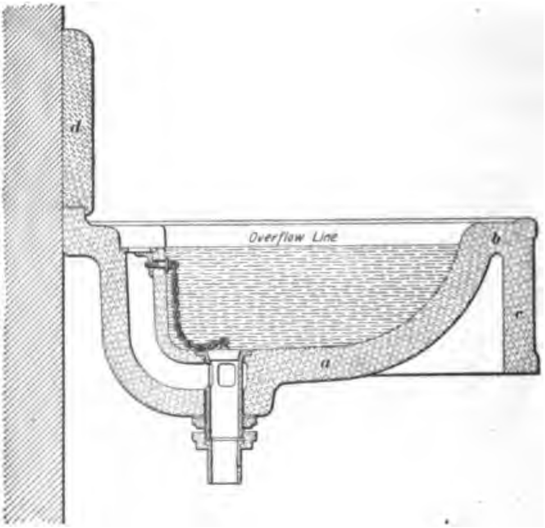

FIG. 37

70. Lavatory Installations.—Fig. 38 shows an all-porcelain **corner lavatory,** supported at each end by a strong iron bracket and at the back corner by an iron bar let into the wall. The hot- and cold-water supply pipes and the waste pipe pass through the wall under the basin. The back plates are cemented to the wall with plaster of Paris. This form of lavatory gives the bather ample elbow room and is preferable to small corner slabs with round basins.

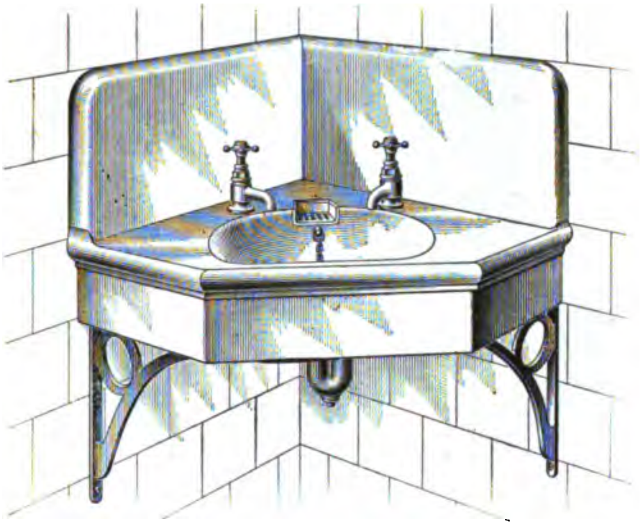

FIG. 38

71. Fig. 39 shows a neat and compact form of basin, or **open lavatory,** as it is commonly called, composed of a 33″ × 24″ × 1¼″ Italian marble slab *a*, with a 16-inch back *b*, 5-inch aprons *c*, *c*, nickel-plated brass legs *d*, *d*, a 19″ × 15″ oval basin *e*, a hot- and cold-water supply combination shampoo *f*, nickel-plated supply pipes *g*, *g*, a waste pipe *h*, and nickel-plated brass apron holders *i*.

The class of lavatory shown in Fig. 39 is recognized as one of the finest and most sanitary on the market. In the highest grade work the slab, back, and aprons may be made of onyx, which has a very rich appearance, and the pipes, trap, legs, apron holders, and cocks may be silver plated or gold plated, according to the finish desired and the amount of money appropriated for the work by the owner.

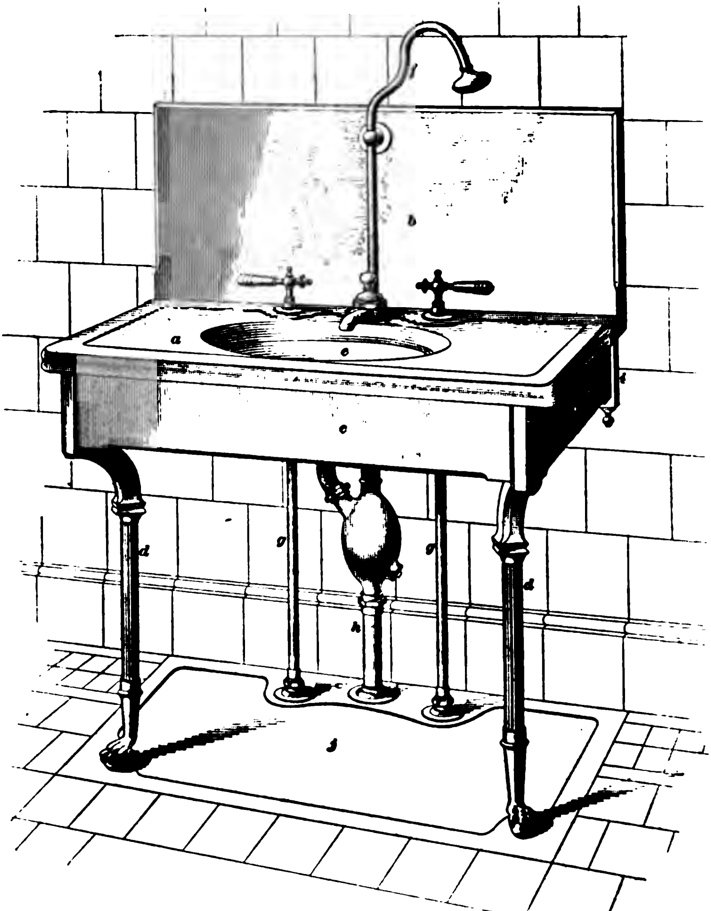

FIG. 39

72. The arrangement of shampoo, waste stand pipe, and hot and cold combination is shown in detail in Fig. 40. The hot-water valve is shown at *a*, and the cold-water valve at *b*. These valves are of the Fuller pattern and are operated by the lever handles shown above the marble slab. Water flows from either valve through the mixing pipe *c* and then through the ring casting *d* before it is ejected from the nozzle. This allows the temperature of the discharge to be controlled by mixing the hot and cold water together. The shampoo attachment *e* is connected to *d* with a swivel or ground joint in such a manner that when it is swung out so as to be over the basin the supply is opened to the shampoo and simultaneously closed to the basin. When the shampoo

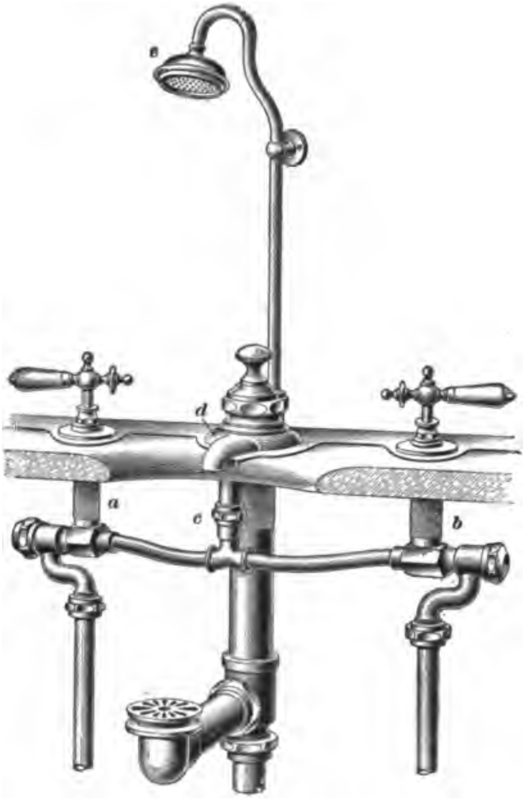

FIG. 40

is swung back against the wall, as shown in Fig. 39, the supply is opened to the basin and closed to the shampoo. The style of supply nozzle shown is preferable to ordinary faucets, because it does not project so far into the basin.

73. When it is desired to obtain a thoroughly sanitary lavatory at as low a cost as possible, a plain wall lavatory on brackets, as shown in Fig. 41, may be used. This combination has a 17″ × 14″ oval bowl; a 30″ × 20″ Italian marble slab countersunk on top and molded on front and ends; a back 12 inches high; common nickel-plated star or cross-handle compression bibbs; a 1½-inch nickel-plated brass trap with a slip joint between trap and bowl; and nickel-plated brass brackets of the pipe form shown, or cast-iron brackets of an ornamental form. Aprons are not used in cheap lavatories.

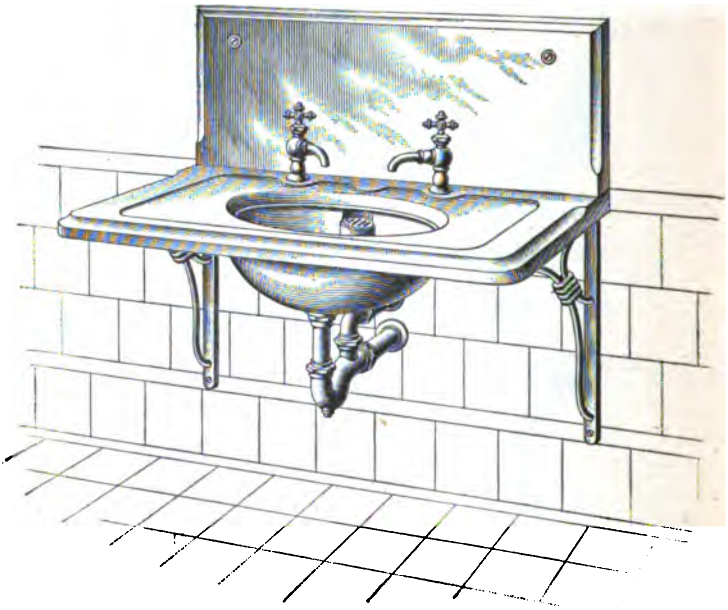

FIG. 41

74. In securing the brackets for basins and sinks, care must be taken to see that solid wood backing is placed in the walls at the proper points, to which the brackets may be rigidly secured. If this is not attended to, the fixture will not be rigid and stable. If brackets are to be attached to a partition composed of the ordinary 2″ × 4″ studding, lathed and plastered, or wainscoted, special 2″ × 4″ blocks should be spiked between the studs. If the walls are of brick or stone, the brackets can be secured with expansion bolts.

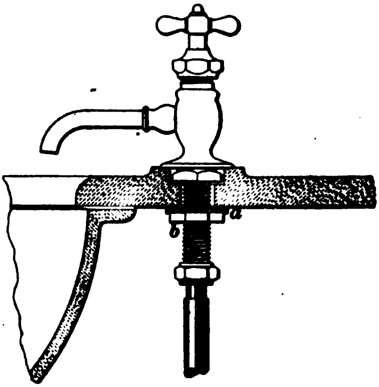

FIG. 42

75. The basin cocks should be attached as shown in Fig. 42, a lead washer *a* being used between the marble slab and the nut *b*. The chain stay should be fastened in the same manner. The cocks and chain stay should be set in plaster of Paris.

76. Bowls are attached to marble or slate top slabs by means of basin clamps *a*, Fig. 43, three clamps being used for a round bowl and four for an oval bowl. The bolts are attached to the slab by means of lead calking. The rim of the bowl is bedded against the slab with plaster of Paris, as at *b*, to make a water-tight joint.

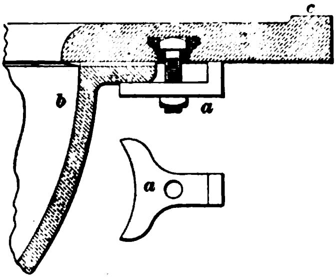

FIG. 43

The proper height of the top of the slab from the floor varies from 30 to 31½ inches, the former generally being satisfactory.

The slab, or top, should have a raised rim around its entire perimeter, as at *c*, so that splashes of water will drain back into the bowl. The holes for basin cocks and other attachments should also be surrounded by raised rims, for the same purpose. The holes for ordinary basin cocks should be made square to receive the square shank of the cock and thus prevent it from turning.

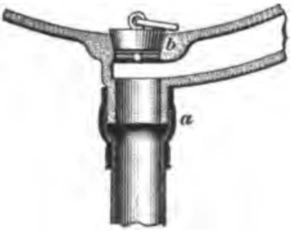

FIG. 44

77. A cheap waste connection can be made by means of a short rubber sleeve *a*, Fig. 44, which is tied or wired to both basin and pipe. This allows the fixtures to settle and shift without danger of rupture, but, nevertheless, this method of making basin connections is not recommended for good work; the rubber soon decays, becomes brittle, and breaks away. The seat, or socket, *b* to receive the plug, when molded in the porcelain, is always more or less imperfect; consequently, a soft-rubber plug is used. The space between the splash plates and the wall should be completely filled with plaster of Paris, so that no crevice or hole is left for vermin.

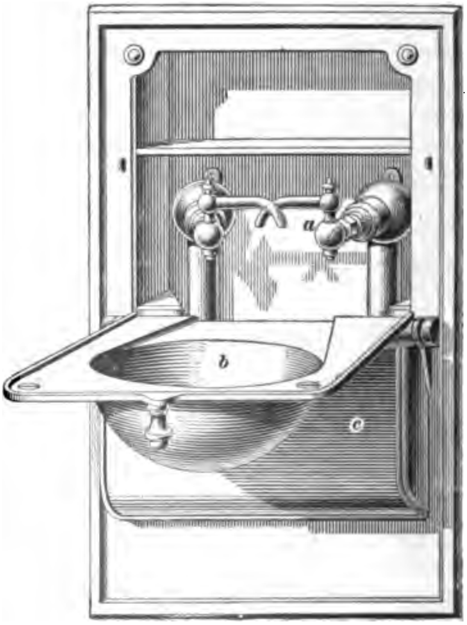

FIG. 45

78. In situations where space must be economized to the utmost, a folding washstand or basin may be employed. The bowl of such an apparatus is hung on hinges, and when not in use may be turned up into a pocket in the wall, as shown in Fig. 45. Two swing cocks at *a* supply hot and cold water to the basin when their nozzles are swung around until they are over it. The water in the wash bowl *b* is emptied into a receiving tank or chamber *c* when the bowl is raised and the apparatus closed, and is carried away by a waste pipe whose trap is immediately under the tank.

RANGE OF WASH BASINS

79. Fig. 46 shows a range of basins very suitable for use in the employe's toilet rooms of large industrial establishments and in public institutions. It consists of a number of solid-porcelain bowls similar to Fig. 37, grouped together and set back to back on cast-iron standards *a*,

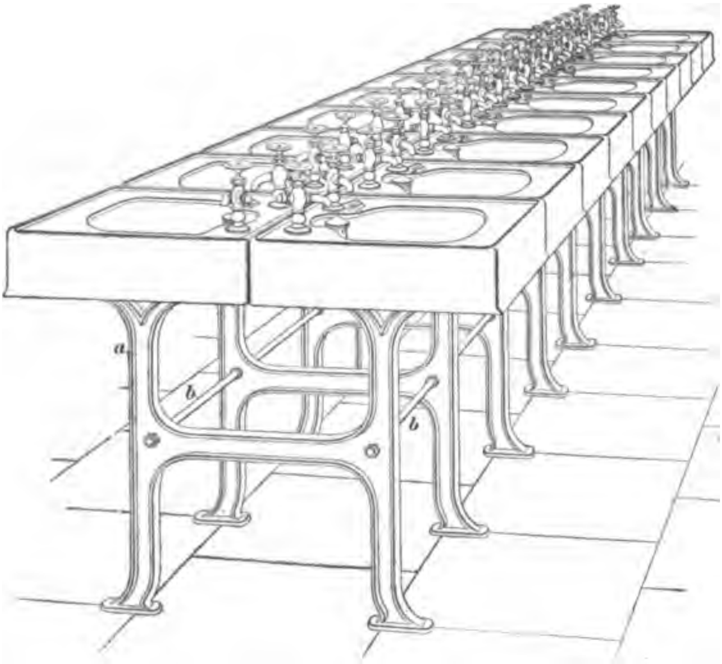

FIG. 46

which are braced by cross-rods *b*, *b*. Each standard has a wide flange cast on top. All the standards, except the two end ones, are set exactly under the joints between the basins, so that the end of each basin is supported on a standard flange. The basins shown are each supplied with a hot and cold spring cock. The wheel handles shown on these cocks are not as desirable as cross- or tee-head handles, because they slip when the hands are soapy. The basins shown are all furnished with standing wastes. One trap is generally used for a range of basins. This arrangement is to be recommended for mill and factory use in preference to wash sinks or cast-iron enameled basin ranges.

LAVATORY DETAILS

80. Marble Basin Slabs.—The slabs, or rather combinations of two or more slabs, used for wash basins are generally made of marble and are known to the trade as follows:

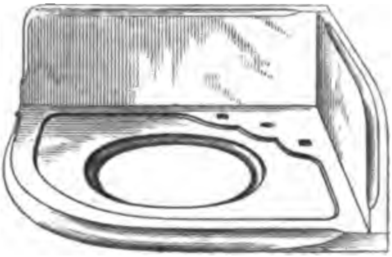

FIG. 47

1. **Round-corner slab with two backs,** as shown in Fig. 47. This style is commonly used in small bathrooms. It is usually supported by cleats nailed under both of the straight ledges of the slab. This basin faces diagonally across the room. The common sizes of these slabs are 18, 19, 20, 21, 22, and 24 inches long at each straight side. The backs are 8, 10, or 12 inches high. The slabs are 1¼ to 1½ inches thick. The backs are ¾ to 1 inch thick.

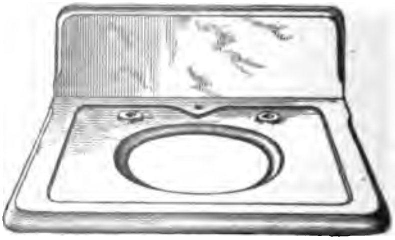

FIG. 48

2. **Slab with single back,** as shown in Fig. 48. This style is intended to be set

against a wall and away from corners. It is preferable to corner basins, because it gives the bather ample space at the fixture. This slab is generally supported at the back by a cleat and in front by legs or brackets.

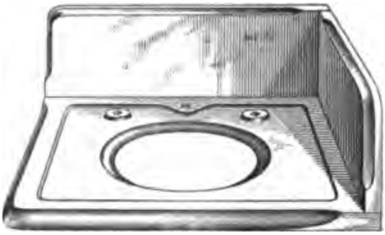
FIG. 49

3. **Right-hand corner slab, or slab with back and right-hand end,** as shown in Fig. 49. It is designated right hand because the side wall is at the right of the person while using the fixture. The back and right-hand end are usually supported on cleats, and the corner by a leg or bracket secured to the wall.

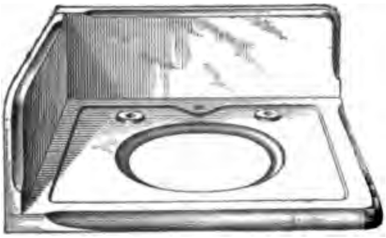
FIG. 50

4. **Left-hand corner slab, or slab with back and left-hand end,** as shown in Fig. 50. What has been said with reference to the right-hand corner slab is applicable to this slab.

The common sizes of slabs shown in Figs. 48, 49, and 50 are 19″ × 24″, 20″ × 24″, 20″ × 26″, 20″ × 28″, 20″ × 30″, 22″ × 28″, 22″ × 30″, 22″ × 36″. The thickness of these slabs is from 1¼ to 1½ inches, and the thickness of the backs is from ¾ to 1 inch. The smaller size in each case is most commonly used.

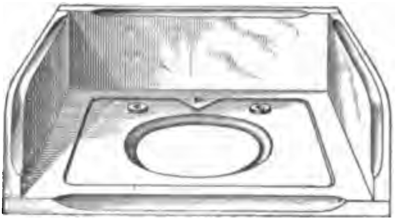
FIG. 51

5. **Recess slab, or slab with back and two ends,** as shown in Fig. 51. It is called **recess** because it is usually set snugly into a recess in the room. Only the front edge of the slab is molded. This slab is supported by cleats under the ends and back; or, the ends

and back may be let into the wall about 1¼ or 2 inches. The sizes of recess slabs depend on the dimensions of the recesses into which they are to be set. These vary so much that it is customary to get slabs especially cut to fit the recesses.

81. Moldings.—There are several forms of moldings employed in the manufacture of marble slabs, the most popular being the **ogee** molding shown in Fig. 52 (*a*). Fig. 52 (*b*) shows the **fillet and chamfer** molding. Fig. 52 (*c*) shows the chamfer molding. Fig. 52 (*d*) shows the **triple bead molding,** the three beads being cut into the exposed edges of the slab, as at *a*, *a*, *a*.

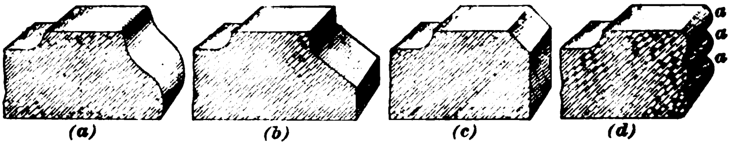

FIG. 52

82. The style of molding used should be selected to match the interior trim of the toilet room. The ogee molding is commonly used when no preference is indicated by architect or owner.

83. Basin Safes.—A special pan of marble or other material is often placed in the floor under a basin for the purpose of receiving drips or leakage from the lavatory. Such a pan is called a **basin safe.** If made of marble, slate, or other kind of stone, or cement, they are countersunk or dished out on top. If made of metal, such as sheet copper or lead, they are provided with a raised rim all around, so that the water falling on the safe will not readily escape to the floor. The safe thus becomes a

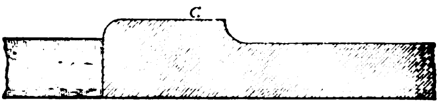

FIG. 53

receptacle to hold a small amount of leakage. A marble floor safe is shown at *j* in Fig. 39. In setting a safe, it is advisable always to sink it in the floor, as shown in Fig. 53, so that the raised portion *a* will be about ¼ inch above the finished floor line; the safe must be set level.

DRINKING FOUNTAINS

TYPES

84. Drinking fountains are used extensively in schools, hotels, large office buildings, barracks, and other buildings where a large number of people congregate. They are seldom used in private residences. There are two kinds of drinking fountains; in the one kind a cup is used to drink from, while the other is provided with a jet from which people may drink without the use of a cup.

85. Objections have been raised by sanitary authorities to the ordinary public drinking-cup method of distributing water. It is stated that the saliva from diseased people adheres to the cup, and is a source of spreading disease among healthy people who drink from the same cup. The question of a hygienic method of distributing pure drinking water to the people is a question worthy of grave consideration. The public-cup fountain certainly is unsanitary, yet a large number of them are in constant use and many more are being installed daily. To overcome the danger of spreading disease by the use of the same cup by all people, it is recommended that each individual carry and use his own cup. The individual-cup method is applicable, however, only for schools, etc., where it is convenient for people to carry their own cups.

CUP FOUNTAINS

86. Marble-Slab Fountains.—Fig. 54 shows a marble-slab fountain, a large number of which are in use. It is composed of a countersunk marble slab *a*, usually about

24 inches long by 12 inches wide. This slab is generally countersunk about 1 inch, and grades down to a waste strainer that is located in the center of the slab. The back slab *b* is about 16 inches high, and is usually ornamental. One or more cold-water ½-inch supply pipes are brought through the back, from which drinking water is drawn through suitable spring cocks. The height of the cock should be about 10 inches above the slab, and the flow of the water should be restricted by a valve or stop-cock on the supply pipe, or by a restricted orifice in the cock, so that the water will flow in a slow, solid, and steady stream, which, when falling on the slab *a*, will not splash over on the floor.

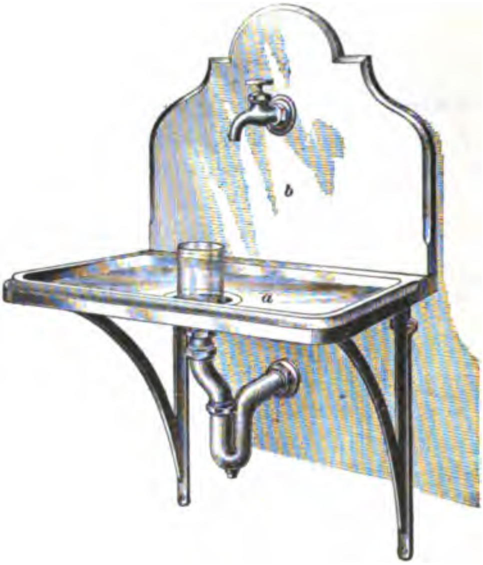

FIG. 54

87. The height that a fountain should be set above the floor depends somewhat on the average stature of the people who will use it. For the use of school children, the height from floor to spring cock should be about 3 feet 6 inches. For the use of adults, the height may be four feet.

88. Porcelain Fountains. — Solid-porcelain roll-rim fountains are often used. They are composed of a bowl and back plate molded in one piece, the cocks being attached to the back, as shown in Fig. 55. Such fountains are usually secured to the wall with nickel-plated, round-head screws and nickel-plated washers, or by nickel-plated lag-screws, or expansion bolts.

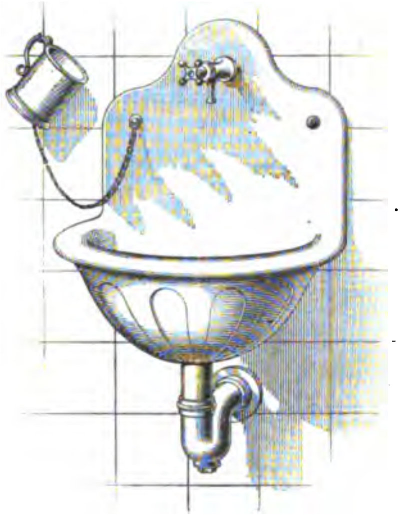

FIG. 55

89. Recessed Fountains.—Recessed fountains are set in the walls, and hence do not project as much as the ordinary fountains, which makes them especially desirable for use in narrow passages or halls. They may be made of marble, porcelain, or other such material. Fig. 56 shows an excellent recessed solid-marble fountain that is simple and substantial. It is cut out of a solid block of marble, the bottom being dished out to a depth of about 3 inches. A waste strainer *a* is located at the lowest point. A marble apron *b* let into the wall and secured with nickel-plated expansion bolts at the corners can be readily removed to give access to the trap. The glass holder *c* and the spring cock for this class of work should preferably be made of first-quality white metal. This metal, when polished, resembles silver and is the same color all through its body. The cocks and glass holders should be frequently scoured and polished to keep them perfectly clean; if they are made of brass and nickel plated, or silver plated, the scouring will remove the plating and show the brass body under it, which is not desirable. White-metal goods may be scoured and polished without affecting their appearance until holes are worn through the metal.

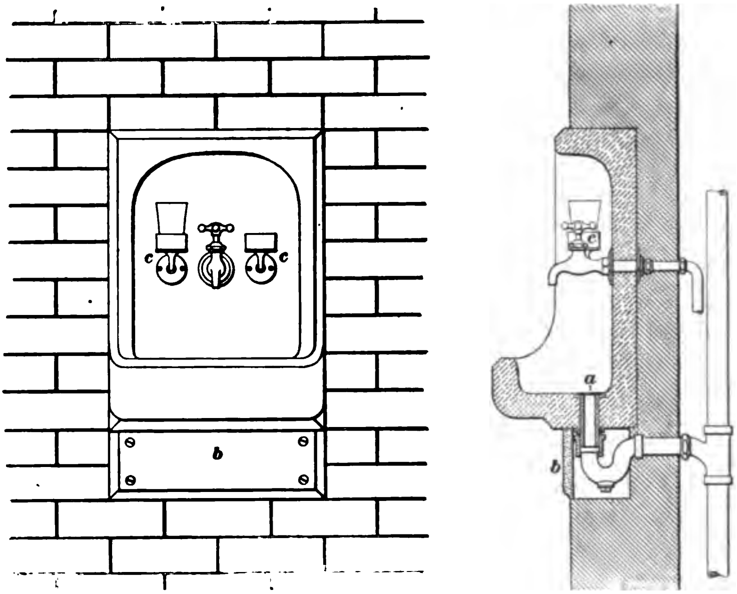

FIG. 56

90. Fountains, like the one shown in Fig. 56, are appropriate for massive construction work, i. e., for buildings that not only are strong but must also *appear* strong; they look particularly neat when set in white-enamelled brick walls.

RISING-JET FOUNTAINS

91. A **cupless,** or **rising-jet, fountain** is a modern fountain, especially constructed to distribute drinking water without the use of drinking cups or glasses of any description. The distribution is effected simply by a rising jet of water like a live spring, from which people may sip water directly from the jet.

Fig. 57 shows such a fountain fitted up complete on brackets secured to a wall. It has a countersunk marble slab, and is fitted with a trap and waste pipe *a*, and a ½-inch water-supply pipe *b*. The valve on *b* is operated by a loose socket key, shown at *c*, which the attendant keeps in his possession. This valve is adjusted to allow a jet of water to rise about 2 inches, as shown at *d*; this is the point where a drink is obtained by stooping over and sucking up water from the jet.

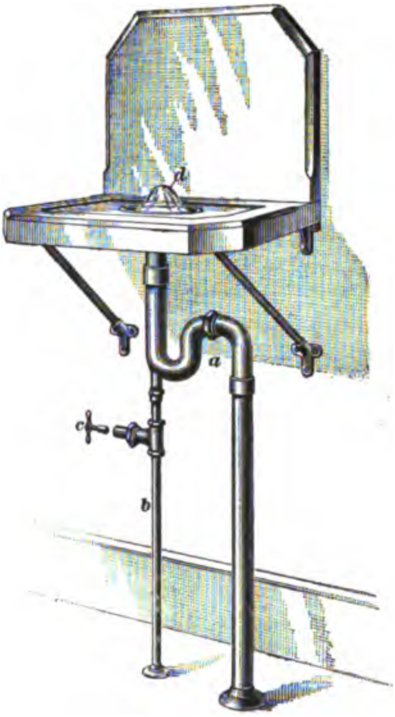

FIG. 57

92. A detail of the jet and waste connections is shown in Fig. 58. A waste cup *a* is countersunk into the marble slab *b*, and is held in place by a special hollow locknut *c* screwed up to the under side of the marble slab. The trap *d* is attached to the waste cup *a* by a coupling joint as shown, and the water pipe is continued up through the inlet end of the trap, terminating with a nozzle below the water in the inner cup *e*. This inner cup is located about ⅛ inch below the level of the waste cup and remains filled with water, as shown. The water flows into the cup and overflows through the waste cup into the trap. A few small holes drilled through the side of the jet cap on top of the water

pipe provide a continuous flush for the inner cup; thus the water in *e* is always clean.

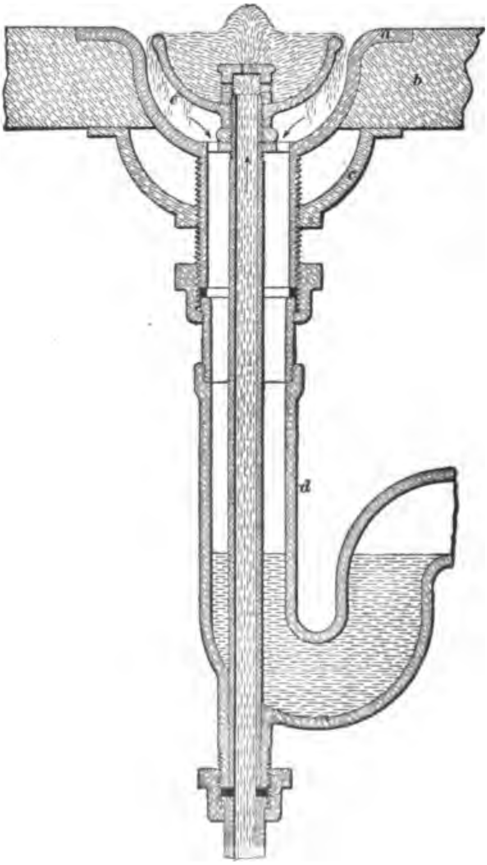

FIG. 58

93. The cupless fountain is suitable for public places, such as schools, colleges, academies, hospitals, office buildings, factories, ferry houses, railroad stations, public parks, etc. For schools it is customary to allow one fountain for 50 scholars.

The cupless fountain prevents the spread of infectious diseases; as the person using it drinks from the flowing water, the lips do not come in contact with any part of the metal, and any impurities from the lips are immediately washed into the waste pipe.

BATHS AND URINALS

BATHS

BATHTUBS

INTRODUCTION

1. The general term **bath** is applied to any **fixture** in which a person can bathe, but in accordance with either the shape or purpose the different fixtures are given specific names by the trade. The fixture generally installed in bathrooms has the form of a tub, whence it derives its name of **bathtub.** Since a person can plunge into the contained water, it is also spoken of as a **plunge bath.**

2. Bathtubs are made in three general styles, which are the *ordinary*, *French*, and *Roman*, the difference being in the shape.

The **ordinary style** has a round bottom, with a sloping **head** and a vertical **foot.** The **French style** has a flat bottom and flat parallel sides, with rounded corners. The head slopes and the foot is vertical. The **Roman style** is rectangular, the sides, bottom, and ends being flat, with round corners. Both the ends and the sides are nearly vertical. The ends usually slope more than the sides.

The ordinary style requires the least water; but, the bottom being semicircular in form, it is of inconvenient shape to stand on. The French tub affords more room for the bather, but requires more water.

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The Roman bath gives the most room for the bather. It is designed chiefly to overcome the unbalanced appearance that the other forms present when fitted up elsewhere than in a corner. In this style, the faucets are nearly always located outside the tub, and the hot and cold water enters through a single opening. The interior space is thus free from all obstructions or projections on which the bather might be injured.

METAL-LINED BATHTUBS

3. Construction.—The cheapest grade of baths are made of wood and lined with zinc or tinned copper. The latter is the most common lining for metal-lined tubs; such a bath is known to the trade as a **copper-lined bath.** Copper-lined bathtubs are from 4½ to 6 feet long, 24 to 26 inches wide, and 20 to 22 inches deep. Such a bath is shown in Fig. 1. It is simply a wooden box lined with tinned copper, the tinning being inside the bath and highly polished. An overflow horn is located at *a*. This bath should be encased with wood finishings and have a special top made to fit the bath and the position in which it is placed.

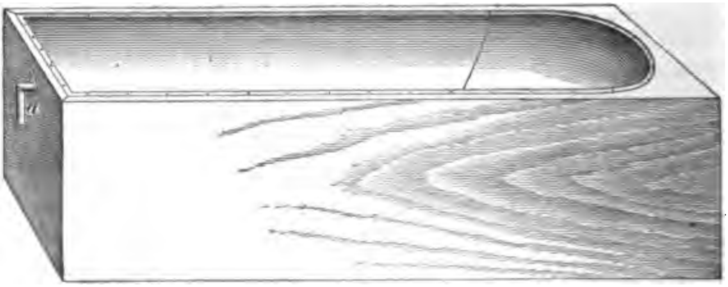

FIG. 1

4. Steel-clad baths are copper-lined or aluminum-lined, the casing being steel. They are supported on four cast-iron feet, have a top rim 3 or 4 inches wide all around, attached to the bath, and have no woodwork around them, being open, and hence are more sanitary than tubs that are enclosed. A sheet of non-conducting material, such as asbestos, is placed between the lining and metallic casing of copper-lined steel-clad baths. The tin coating soon wears off and exposes the copper. A harder and more durable coating is secured by nickel plating.

5. Waste Connections.—The **waste pipe** is always connected to the bottom of the tub, and should be provided with a **strainer** to prevent the passage of soap, rags, etc. into the trap. The mode of connecting the waste pipe to a common copper-lined bath is shown in Fig. 2. The wooden bottom *a* is countersunk, and the copper lining *b* is also countersunk to suit. The waste pipe *c*, which should not be less than 1½ inches inside diameter, is flanged over, as shown. The brass socket *d* is provided with cross-bars *e* that serve as a strainer, and is ground to a water-tight fit with the plug *f*. The space *g* is filled with solder, flush with the lining.

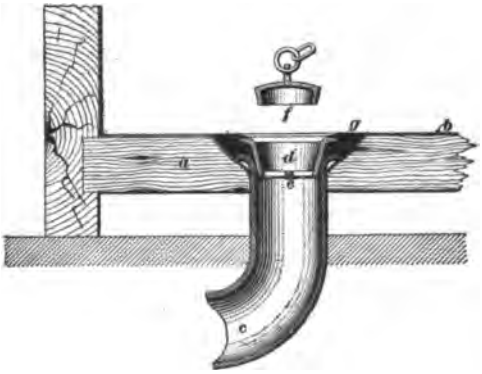

FIG. 2

6. All tubs should be provided with an **overflow pipe** having a perforated plate or strainer over its mouth to keep out soap, etc. A common form of a **copper-lined tub connection** is shown in Fig. 3. The bath empties through the 1½-inch waste pipe *a* and through the 1½-inch half S trap *b* into the drainage system. A 1¼-inch lead overflow pipe *c* connects the copper overflow-pipe horn *d* to the trap.

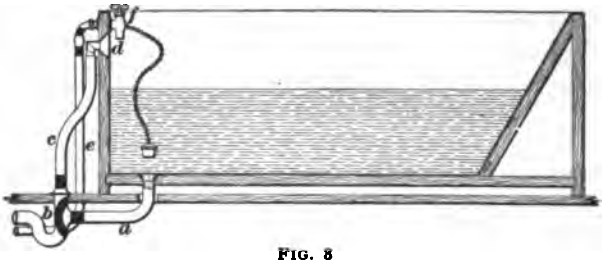

FIG. 3

A ⅝-inch or ¾-inch pipe *e* supplies the bath with water through the bath cock *f*.

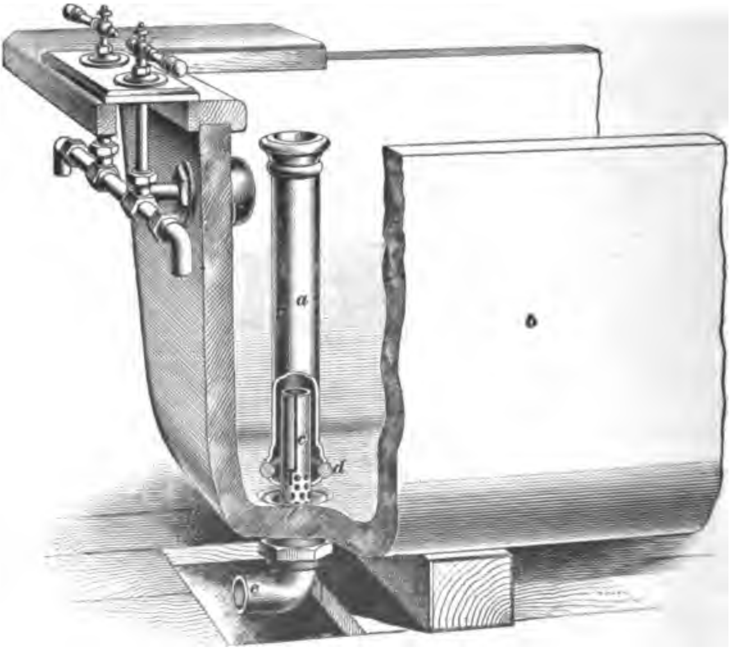

FIG. 4

7. Standing overflow and waste pipes, as shown in Fig. 4, are frequently used. The overflowing water passes over the top of the standing tube *a*, and when the tub *b* is to be emptied, the tube is pulled upwards, thus uncovering the perforations at the bottom of the inner tube *c*, as shown. The outer tube is provided with a rubber ring *d*, which makes a water-tight joint with the seat when it is dropped down on the bottom. A bent coupling *e* is shown attached to the waste outlet. If desired, a straight coupling may be used. This coupling connects with the bath trap, which is not shown.

8. The waste connection shown in Fig. 4 is most commonly used with the earthenware, porcelain, or cast-iron baths. A combination that is especially suited to copper-lined baths is shown in Fig. 5. The stand-pipe overflow *a* is arranged at the top so that it passes through a sleeve in the mixing pipe of the **combination bath cock** *b*. The valve is opened by pulling up the cup handle *c*. This arrangement steadies the standing waste and makes it positively secure. Fig. 5 shows a cross-section through a copper-lined French bath.

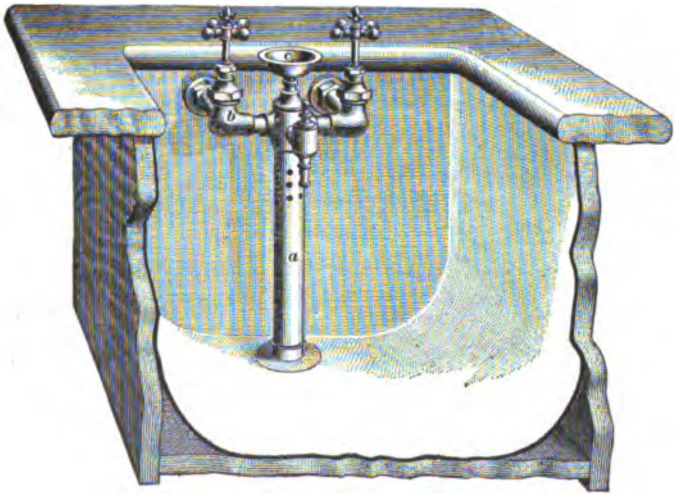

FIG. 5

9. **A stand-pipe combination of waste and overflow** is shown in Fig. 6. The tube *a* is provided with a rubber ring *b* that shuts water-tight upon the seat *c*. The water rises between the tubes *a* and *d* to the same height that it does in the bath until it reaches the perforations *e*; it overflows through these and passes down the interior of *a* to the waste pipe. The inner tube is provided with a handle *f* having a suitable slot and catch, commonly known as a **bayonet catch,** by which it can be lifted and suspended, as shown. Combined waste and overflow devices are adapted to all kinds of bathtubs, whether of wood, metal, or porcelain.

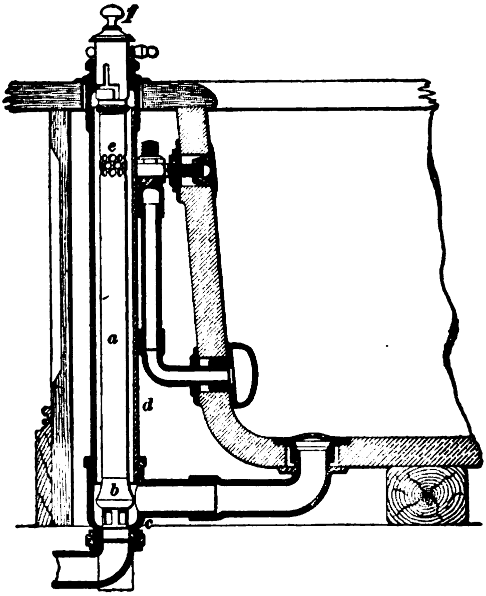

FIG. 6

10. Bathtubs that are to be cased in are, in good work, set on a copper or lead safe. Those that are to be left open, in the best practice, are set on marble safes or on a floor of some impervious material. In either case, the bathtub should be set on the floor with a slight pitch toward the waste outlet. Marble safes are usually dished out to a depth of ¼ or ⅜ inch, and have a brass strainer connection to a waste pipe. They should always be set at a small inclination, so that the water will drain properly toward the waste strainer.

11. Supply Connections.—The hot and cold water may enter the bath through separate faucets. The water is, however, generally delivered to the bath through a single bath cock composed of the hot and cold shut-off valves joined together into one discharge nozzle. Such a fixture is usually nickel-plated and is known as a **combination bath cock.** The valves of the cock may be inside or outside the bath. Ground key cocks are seldom used as bath cocks, Fuller and compression valves being mostly used instead. An outside Fuller combination bath cock is shown in Fig. 4. An inside compression combination bath cock is shown in Fig. 5. The faucets that are used to control the water supply are either of the Fuller or compression type; plug cocks are used only on very low water-pressure work.

In the best grade of fittings, angle valves with brass screw-joint connections are employed, and they are arranged to deliver water into the tub through the same nozzle. All the valves and pipes are thus located outside of the tub, and the whole interior space is free from obstructions.

12. It is quite common practice to arrange the bath cocks so that they will supply the bath from points near the bottom, as shown in Figs. 6 and 9. This method is certainly less noisy than that in which the nozzles are always above the water in the bath, but it nevertheless has a disadvantage that should prohibit its general use. For instance, suppose the bath to be full of foul water and soap, etc.; a heavy draft is then made on the main by somebody opening faucets at lower levels. The bath water will immediately be ***sucked***, as it were, up through the combination cock (if it is open) and then be siphoned down through the supply pipes, thus contaminating them.

13. Sometimes the hot-water and cold-water faucets are connected to deliver into the outer shell of the standing waste, so as to supply the tub through the waste-pipe strainer. This is a bad plan, because when the tub is emptied the water passes out first and all soap or refuse goes last. This refuse tends to lodge in the waste pipe, and will be washed back into the tub when fresh water is introduced in that way.

14. Fig. 7 shows the arrangement of the connections to a Roman bathtub *a*. The standing waste *b*, the hot-water faucet *c*, and the cold-water faucet *d* are placed at the side of the tub, between it and the wall. The mingled hot and cold water enters through the single nozzle *e*, which is usually made in the form of a shell, as shown in the section to the left of the figure. The hot-water circulation pipe *f*, the waste pipe *g*, the trap *h*, and the trap vent *i* are connected as shown. The standing waste *b* was shown to an enlarged scale and in section in Fig. 6.

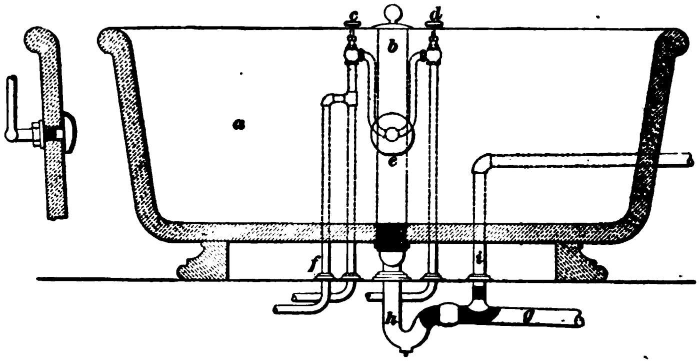

FIG. 7

SOLID BATHTUBS

15. Form of Rims.—Metal and porcelain tubs are made with two styles of rims. The **plain rim** *a*, Fig. 8 (*a*), needs a wooden top or rail *b* to cover the square edges, protect the bather, and improve the appearance. The wooden top may be secured to the rim of an iron tub by clamps *c*, as shown. The **roll rim,** shown in Fig. 8 (*b*), requires no other finish, will not decay, and does not harbor vermin.

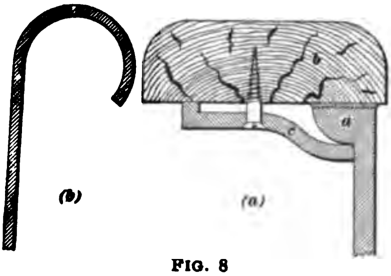

FIG. 8

16. Cast-Iron Enameled Bathtub.—Fig. 9 shows an excellent cast-iron roll-rim enameled bath, with nickel-plated standing waste, hot and cold combination, and low-down supply, all open and quite accessible for cleaning and repairs. The bath is supported by four ornamental cast-iron feet and is set on a countersunk marble safe. This bath is

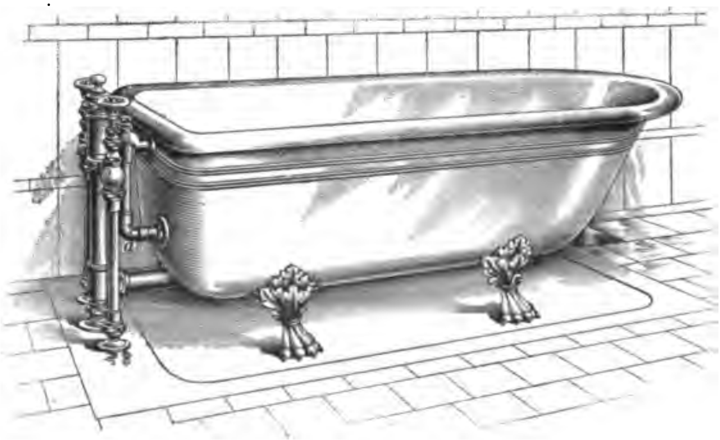

FIG. 9

painted outside with enamel paint; the interior surface and the roll rim are coated with porcelain enamel.

Cast-iron bathtubs are usually about the same length as metal-lined bathtubs; that is, they range from 4½ to 6 feet in length; they are generally shallower, being as a rule about 19 inches deep.

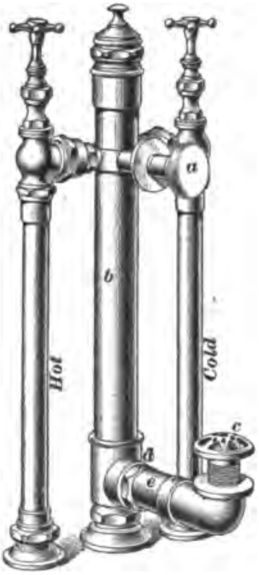

FIG. 10

The bathtub and connections here shown are commonly used on plain substantial work where economy is an important feature. They are to be recommended for places where the city pressure is constant. If the pressure is intermittent, and if there is liability of the water in the house-supply pipes being drained back to the street main, it would be advisable to dispense with the low-down inlet *a* and place it above the bath water-line.

17. Bath Supply and Waste Combination.—Fig. 10 shows a bath supply and waste combination that will prevent the water in the bath from draining back into the supply pipes. The inlet opening to the bath is at *a*, which, being higher than the overflow perforations in the standing waste tube of the stand pipe *b*, is always above the water in the bath. The waste grating is at *c*. In this combination a slip joint is made at *d*, which allows the waste pipe *c e* to be adjusted in length to suit the hole in the bottom of the bath.

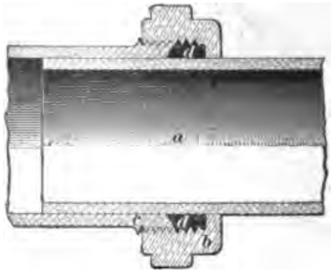

FIG. 11

18. Fig. 11 shows a sectional view of the slip joint. The waste pipe *a* is first attached rigidly to the waste hole in the bottom of the bath; the ring coupling *b* is then screwed tightly on the casting *c* at the base of the stand pipe, and a soft-rubber ring *d* is thus pressed firmly against *c* and *a*, which makes the joint water-tight.

19. A bathtub more costly than, and decidedly superior to, those previously illustrated is shown in Fig. 12. It is made of solid porcelain, and glazed both outside and inside. This is known as an **all-porcelain roll-rim bath,** and has a low-down supply combination *a* and a standing waste *b*. The crosshead handles of the valves are ivory mounted and marked "Hot" and "Cold." A special

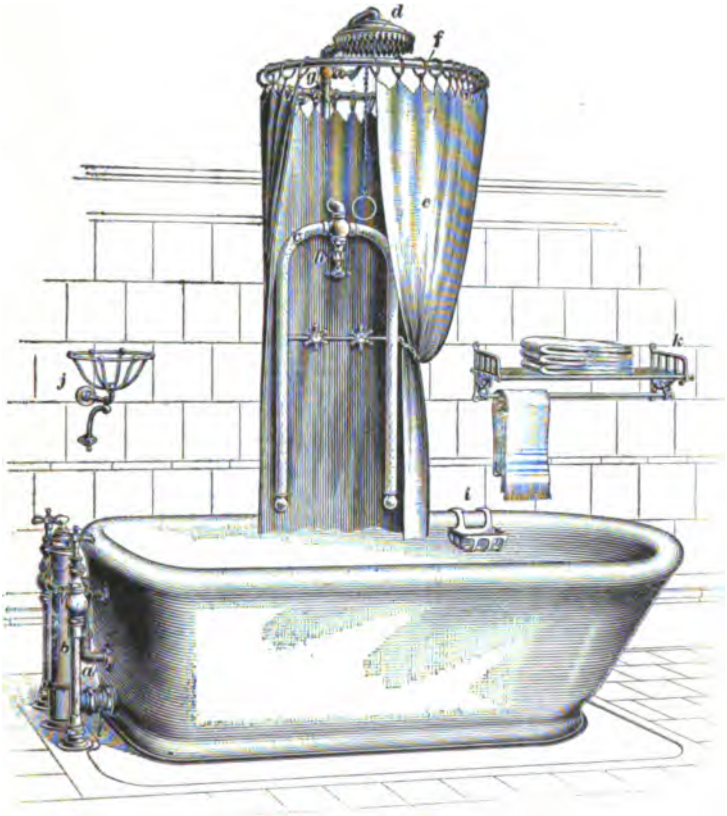

FIG. 12

feature of the equipment of this bathtub is the combination spray *c* and shower *d*, a white-rubber curtain *e*, and a nickel-plated brass curtain holder *f* that is attached to the mixing pipe *g* of the shower. In this combination, it is only necessary for the bather to draw the curtain forwards and operate the handles of the valves that come through the back of the curtain. This enables him to govern the volume and temperature of the water as he stands within the curtain. The valves at the foot of the bath supply the plunge, i. e., they fill the bath. The two valves at the back of the curtain control the hot and cold water both to the shower *d* overhead and the spray tubes *c* inside the curtain. The inverted valve *h* to which the spray tubes are joined controls the volume of water to the spray from the mixing tube *g* that runs up back of the curtain and supplies the shower *d*. A special shower spring cock provided with a chain-and-ring pull is attached to the top of the mixing tube, as shown. Therefore, to obtain a shower, it is necessary to pull the chain.

To prevent the bather from being scalded by turning the hot valve full open by mistake, a mixing chamber, provided with a thermometer, is sometimes attached to the mixing tube at the point where the hot and cold cocks join. The thermometer bulb must be in the current of the water, but the graduated stem is secured inside the curtain so that the bather may know the temperature of the water before it strikes him.

To complete the equipment, a soap dish *i*, sponge rack *j*, and towel rack *k* are usually provided. These the plumber will secure to the tiled walls with brass expansion bolts, except the soap dish, which may hang on the roll rim, as shown.

Porcelain bathtubs are usually about 30 inches wide at the head, 24 inches wide at the foot, and about 22 inches deep. They are quite heavy, a tub 5½ feet long weighing about 600 pounds. In Fig. 12 the waste pipe *l* has a slip joint between the bath and the stand pipe; a support is let into the porcelain and made fast to steady the stand pipe and the supply pipes.

SPECIAL FORMS OF BATHTUBS

20. Sitz, or Seat, Baths.—A special form of bathtub that is of smaller dimensions than the plunge baths previously described, being from 24 inches to 27 inches long, 22 inches wide, and 12 inches to 17 inches high at the front edge, when set up, is known as a **sitz, or seat, bath.** The back is usually 6 inches, or more, higher than the front.

The sitz bath is fitted up with hot- and cold-water and waste connections in a manner similar to those already shown and described for plunge baths. The hot and cold water mixes and enters by the tube *a*, Fig. 13. The waste water leaves the bath through *b*. A base *c* supports the bath, but legs may be used if desired. Sitz baths are fitted up in bathrooms that contain the usual other fixtures, such as baths and lavatories, in order to make the equipment more complete.

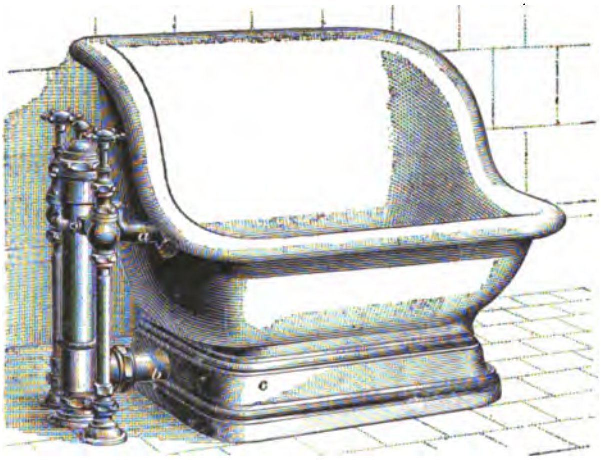

FIG. 13

21. Foot-Baths.—A bathtub intended to be used only for washing the feet is known as a **foot-bath.** Such tubs are of about the same dimensions as seat baths; some, however, are only 17 in. × 19 in., and 10 inches deep.

Seat and foot-baths are constructed of the same materials, are connected to the waste pipes in the same way, and are provided with the same fittings as the full-size baths. Fig. 14 shows a foot-bath of approved make. It is furnished with hot- and cold-water supply fittings and a combination stand-pipe waste at the back, the knob *a* being the top of the standing waste and *b* a hollow shell through which water enters the foot-bath. This style of fixture is usually fitted up in bathrooms intended to be very complete in their appointments.

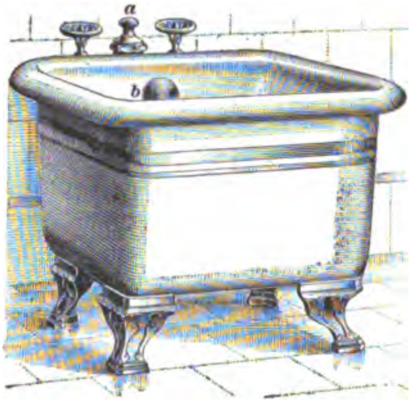

FIG. 14

BIDETS

22. Bidets.—A pan having a seat like a water closet and a jet of water that is projected upwards, as shown in Fig. 15, is known as a **bidet.** The pans are made of porcelain or copper, and are also made in one piece with the support, as shown in the illustration. They are usually fitted with hot- and cold-water connections and with a mixing pipe that should have a thermometer attached to indicate the temperature of the water.

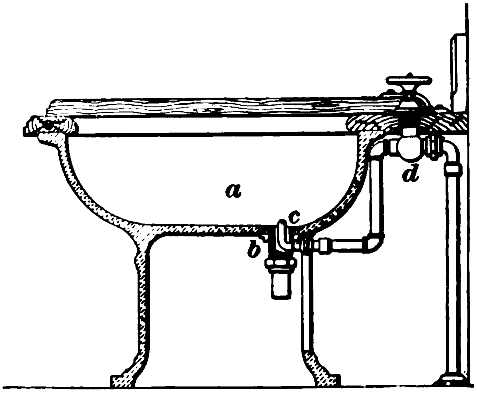

FIG. 15

Sometimes the pans are fitted with a standing overflow and waste plug, by which water may be retained in the pan. In Fig. 15 the bowl, or pan, *a*, is fitted with an open waste connection *b*, through which projects a small jet nozzle *c*. The force of the jet of water ejected from *c* is governed by the valve *d*.

23. To have the use of a bidet jet without a special bidet bowl, as in Fig. 15, a bidet cock can be attached to an ordinary water-closet seat *a*, Fig. 16, by means of a clamp *b* secured to its under side. The ground cock *c* to which the jet arm *d* is attached works on a swivel in such a manner that when the handle *e* lies in the cup, and the jet arm *d* is consequently raised to a horizontal position at the back of the closet bowl *g*, as shown by the dotted lines, the water will be shut off and *d* will be concealed under the seat. This attachment is usually supplied with cold water only. A small drip-pipe coupling *h* is generally connected to a ½-inch waste tube to carry off any drippings from *c*.

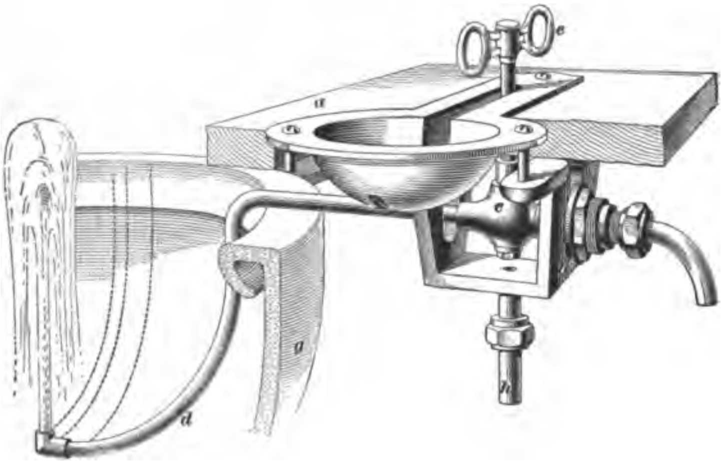

FIG. 16

SHOWER BATHS

CONSTRUCTION

24. Definition and Advantages.—A bath in which a person can subject himself to a shower or spray of water from overhead is known as a **shower bath.** Shower baths, also sometimes called **rain baths,** are especially adapted for public bathing establishments. They have an advantage over plunge baths for such places in that they occupy but little floor area; furthermore, they are thoroughly hygienic, as the same water never comes in contact with the body twice.

Some people make a distinction between shower baths and rain baths, applying the former term to a bath delivering the water in large drops at a low velocity, and the latter term to one in which the water is delivered downwards in minute jets at a high velocity.

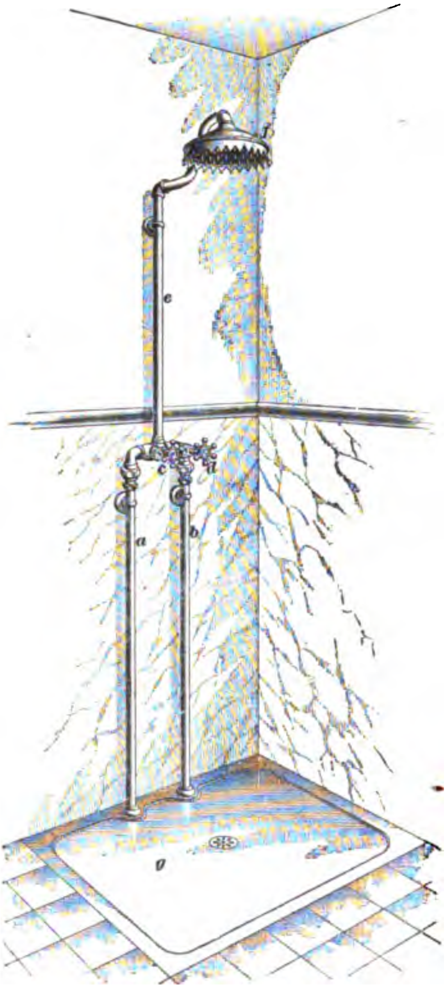

FIG. 17

25. Simple Shower Baths.—Fig. 17 shows a simple form of shower bath. It is composed of a hot-water supply pipe *a*, a cold-water supply pipe *b*, a hot-water valve *c*, a cold-water valve *d*, a mixing pipe *e*, a plain spun-copper **shower** *f*, and a marble safe *g* with a strainer and waste connection at the center. The pipes, valves, and showers are usually nickel-plated. The valves should always be marked "Hot" and "Cold."

26. Fig. 18 shows the inside construction of the shower *f* in Fig. 17. Water enters the shower through *a*, which has holes drilled through the side, as shown. The air collecting in the top of the shower escapes through *b*; the water flows uniformly out of the numerous small tubes and thus produces artificial rain, or a shower. The body of the shower should be in two parts and connected with a thread at the joint *c*, so that the lower part may be removed and cleaned should the small tubes become clogged. There are cheaper forms of showers, some being similar to the sprinkler or **rose** of an ordinary watering pot for sprinkling flowers, but that shown in Fig. 18 is one of the best.

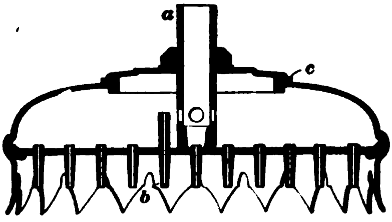

FIG. 18

27. The common sizes of showers are, in diameter, 8½ inches for a ½-inch supply pipe, 10½ inches for a ¾-inch pipe, 14 inches for a 1-inch pipe, and 16 inches for a 1¼-inch pipe.

28. Shower and Shampoo Baths.—Fig. 19 shows a shower and shampoo combination with a brass-tube ring from which a white rubber curtain is hung by means of curtain rings and hooks. The ring *a* is perforated at the under side to form the shower; it is supplied by the mixing pipe *b*. The spray nozzle *c* is called a **shampoo.** It is fed by a ½-inch rubber tube *d* from the lower end of the mixing pipe. The shampoo head is hung on the key of the cock that supplies it, the crosshead of the cock being made in the form of a **U**. A **receptor** *e* is shown instead of a floor-slab safe. This may be made of porcelain or enameled cast iron. The bottom is slightly graded down to the safe waste strainer or grating *f* in the center. It is a roll-rim fixture, and is supported, a few inches above the floor, on four legs. It may, or may not, be furnished with a standing waste and combination supply cocks.

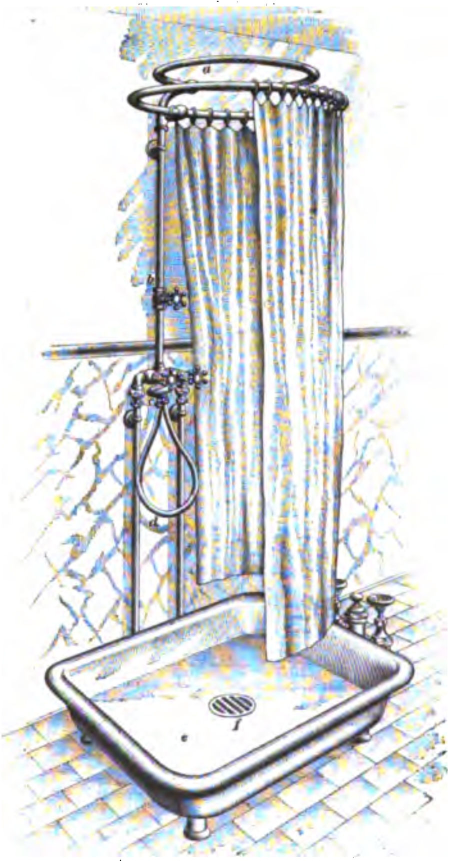

FIG. 19

29. Needle Bath. A combination shower and spray, or **needle bath,** is shown in Fig. 20. The hot-water pipe is shown at *a*, and the cold-water pipe at *b*. The tubes *c* are perforated and form the spray or needle bath. The volume of the spray from all these pipes is controlled by the valve *d*. The three lower pipes *c* are supplied direct from the vertical pipe or standard to which the valve *d* is attached. The supply to the upper pipe *c'* passes up through the inside of the front standards, as shown by the arrows, blind washers being inserted at the two unions below the valve *f*. The volume of the spray from the shower *e* is controlled by the valve *f*. The temperature of the spray and shower is regulated by adjusting the flow of the hot and cold water through the supply valves on *a* and *b*. A soap holder is shown at *g*.

This is a nice, simple combination that is often used in private residences. If the bathroom floor is tiled, the combination is usually set on a marble safe, as shown. If it is not tiled or otherwise made water-tight, a receptor is commonly used to protect the floor. If the walls are tiled, the curtain may be dispensed with or it may be used simply for privacy.

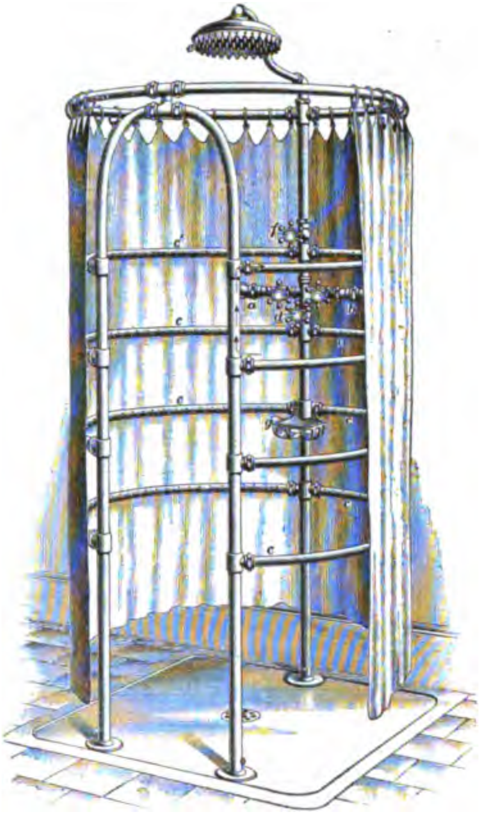

FIG. 20

30. Combination Shower Bath. A combination shower, douche, spray, bidet, and liver-spray bath is shown in Fig. 21, as set in a right-hand corner, a marble slab *a* forming a partition at the left. This is a very complete and efficient appliance. It is designed chiefly for use in Turkish and Russian bathing establishments and hotels, but it is, nevertheless, well adapted for use in bathrooms of fine residences.

Five different forms of baths can be had from this fixture. By opening the hot and cold supply valves *b* and *c*, a mixture of hot and cold water at the desired temperature flows into the header *d* and is ready to flow through either of the

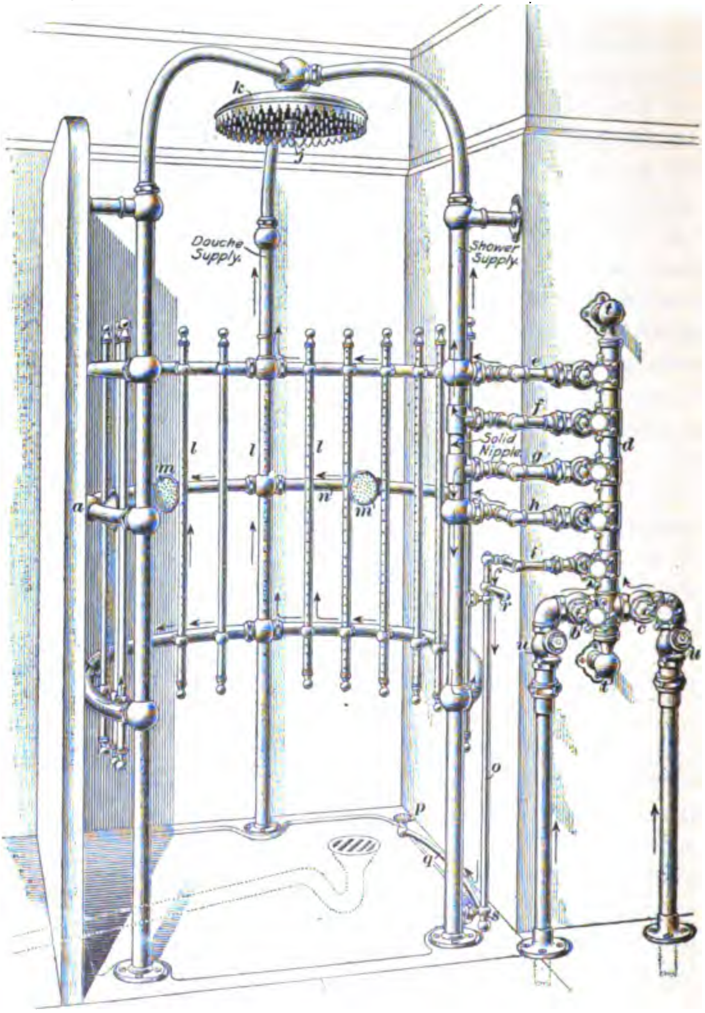

FIG. 21

pipes *e*, *f*, *g*, *h*, and *i*. If the valve on *e* is open, the water in *d* will flow to the douche *j*, from which it will fall on the bather, who stands directly under it. The douche throws a full-bore stream that is not broken by perforations. If the valve on *f* is open, the water in *d* will flow to the shower *k*, from which it will fall on the bather in the form of rain. If the valve on the pipe *g* is open, the water in *d* will flow from the spray tubes *l*, *l* against the sides, back, or front of the bather. These tubes are perforated with numerous small holes, each of which throws a stream of water about as thick as a needle; hence the term *needle bath*, which is often used instead of *spray bath*. The tubes should be detachable, so that they may be easily uncoupled and cleaned out should the holes become clogged. If the valve on the pipe *h* is open, water will flow from *d* to the **liver sprays,** or **rose sprays,** *m*, *m*, which are supplied through the horizontal tube *n*. These roses throw a strong spray against the sides of the bather. If the valve on the pipe *i* is open, water will flow from *d* down through a $\frac{1}{2}$-inch or $\frac{3}{8}$-inch tube *o* to a **bath bidet** *p*, which is a small sprinkler or jet that ejects water vertically upwards. When it is desired to use the bidet, the arm *q* is swung around by means of the handle *r* to about the middle of the safe. It swings on a swivel joint at *s*. A floor douche is similar to a bidet, but throws a large stream instead of spray.

The header or branch manifold *d* is secured to the wall at the top and bottom by special brass-flanged caps *t*, *t'*. Check-valves *u*, *u* are placed on the supply pipes to prevent hot water from entering the cold-water pipes and cold water from entering the hot-water pipes, if the hot-supply and cold-supply valves are open and all the other valves closed. The valves may be at the right, as shown, or at the left, or in any convenient place to suit the arrangement desired or the shape of the room.

31. Mixing Chamber.—In all spray, needle, shower, or rain baths, and shampoos, it is advisable to use not only a mixing pipe, but also a mixing chamber, so that the hot and cold water will become thoroughly mixed before it reaches the bather and thus avoid danger of scalding. A thermometer, with its bulb in the chamber, should be attached, to indicate the temperature of the water before it is ejected against the bather.

32. A mixing chamber in combination with a shower head and a shampoo is shown in Fig. 22. Cold water entering through *a* and hot water entering through *b* are admitted to the chamber *c* in small jets and thoroughly mixed before passing into the discharge pipe *d*, the top of which discharges through the shower or the shampoo attachment, as desired. A thermometer *e* has its bulb extending into a circuit or current of mixing water to indicate the temperature of the mixture.

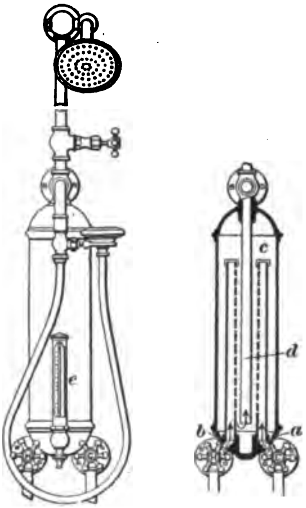

FIG. 22

33. Multiple Rain Bath. Fig. 23 shows a simple method of connecting up multiple rain baths and a mixing chamber, such as is frequently used in hospitals, asylums, etc. A galvanized-iron cylinder *a* is used for a mixing chamber. Hot and cold water enter this chamber through the pipes *b* and *c*. The pipe *d* is a waste pipe through which water may be run off to regulate the temperature of the water before it is allowed to go to rain baths *e*, *e*, etc. The thermometer is located at *f*. Each rain bath is supplied separately from a header *g*, and the controlling valves *h* are placed within reach of the attendant. The rain baths shown can be made to discharge at any angle desired, because they work on a swivel with ground ball joints. For five rain baths, as shown, a convenient size for the mixing chamber is about 25 gallons, or 5 gallons to each rain bath. The height of a shower, or rain, bath is 7 feet 6 inches from the floor. If they are constructed in stalls, i. e., with partitions between them, they should be about 3 feet apart. The mixing chamber may be drained through the drain pipe *i* that is connected to the waste pipe *d*.

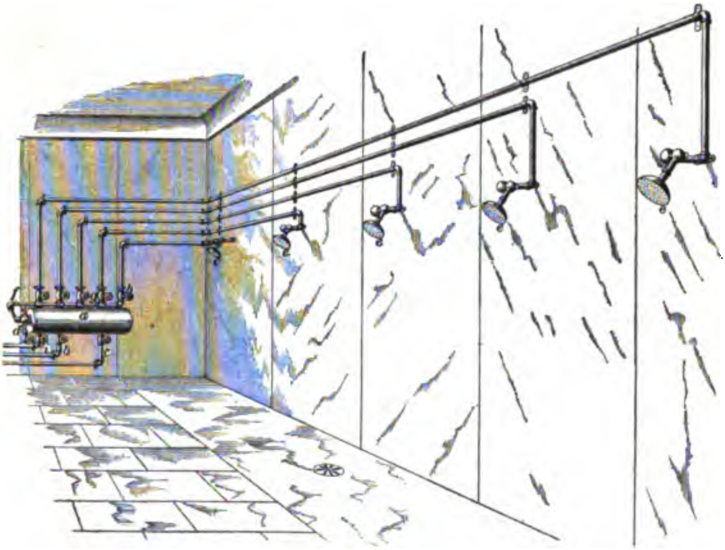

FIG. 23

BATHROOM ARRANGEMENTS

INTRODUCTION

34. Most modern bathrooms are provided with tiled floors and often, also, with tiled walls, and the plumbing appliances are all open and accessible in every part, thereby insuring not only practical usefulness, but cleanliness, beauty, and convenience. Tiled walls, porcelain fixtures, nickel-plated brass pipes, and open work are the main features of strictly modern bathrooms in high-grade work.

SMALL BATHROOM EQUIPMENT

35. The arrangement of the fixtures in a bathroom is a very important subject and is worthy of study. Fig. 24 shows how a small bathroom can be equipped with a cheap, yet sanitary, water closet, wash basin, and bath. It is thoroughly suited for buildings that cost about $2,500 or less. The water closet *a* is an all-porcelain front outlet closet of the washout type. The tank *b* is a siphon tank made of cherry, ash, or oak, and is lined with 14-ounce plain

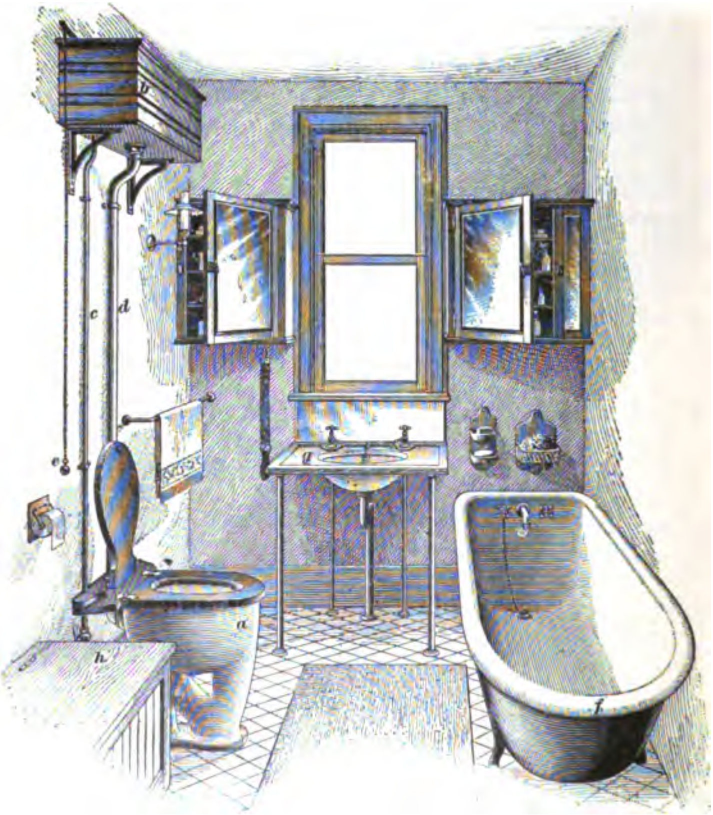

FIG. 24

copper. The supply pipe *c* and flush pipe *d* are made of lead or nickel-plated brass. The closet is operated by the chain and pull *e*. The bath *f* may be either steel and copper-lined, with a wooden frame on top, or it may be a second-quality cast-iron enameled bath. A combination cock, a plug and socket, and an overflow attachment are placed at the foot of the bath. The basin *g* is oval and has a patent overflow, plug socket, and chain. The basin cocks are of the common compression class and have crossheads. The basin trap, waste pipe, its vent connection, and hot and cold supply pipes above the floor may be lead or nickel-plated brass. The basin legs are simply pieces of 1-inch black iron pipe, bronzed, and let into the marble basin slab about ⅜-inch on top, and screwed to the floor with flanges at the bottom. This bathroom is shown equipped with two convenient cases, one on each side of the window, at such a height that the mirrors that form the doors for these cases can be conveniently used while shaving or for other toilet purposes. A chute closed by the cover *h* leads to the laundry below; soiled wearing apparel is thrown into this chute.

If porcelain goods are used in bathrooms of this class, they may be of the grade known as **C**, if purchased from a first-class supply house; otherwise, they should be of class **B**.

MEDIUM-GRADE BATHROOM EQUIPMENT

36. The equipment of a bathroom suitable for a $10,000 house is shown in Fig. 25. The bath *a* is of enameled iron and has a roll rim. It is painted outside and furnished with a nickel-plated combination faucet *b*, overflow and waste, a chain, and a rubber stopper inside (rubber is preferable to brass for a stopper, as it does not chip the enamel). The basin *c* is all porcelain with a porcelain back; it has low-down compression faucets *d*, *d*, with name plates marked "Hot" and "Cold," and an adjustable brass 1½-inch half **S** trap *e*. The legs *f* may be enameled iron or nickel-plated brass. A good size for this basin is about 27 in. × 22 in.

The water closet *g* is of the siphon-jet class, with quartered-oak seat, cover, and tank. The flush pipe *h* is 1¼-inch nickel-plated brass. The floor is tiled and made water-tight. The walls also are tiled as high as the window sill, a molded tile cap being secured on top and a molded base at the bottom. All the lavatory fittings, such as towel racks *i*, *i*, sponge holder *j*, and paper holder *k* are nickel-plated brass.

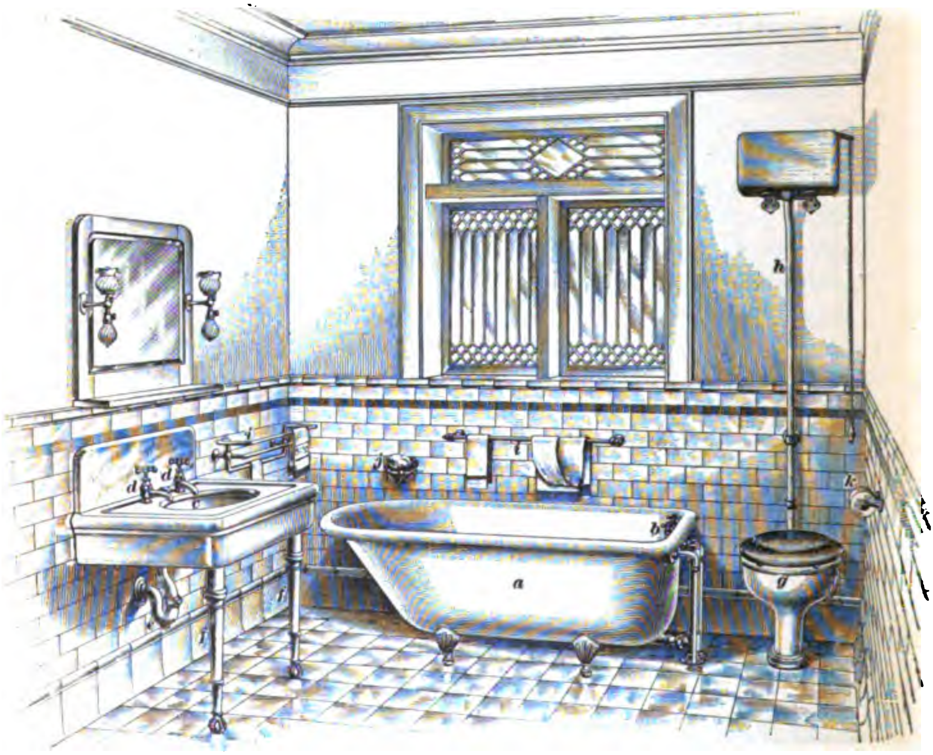

FIG. 25

In bathrooms of this class the porcelain fixtures may be of the class known as **B** provided they are purchased from a first-class supply house; otherwise, they should be of class **A**.

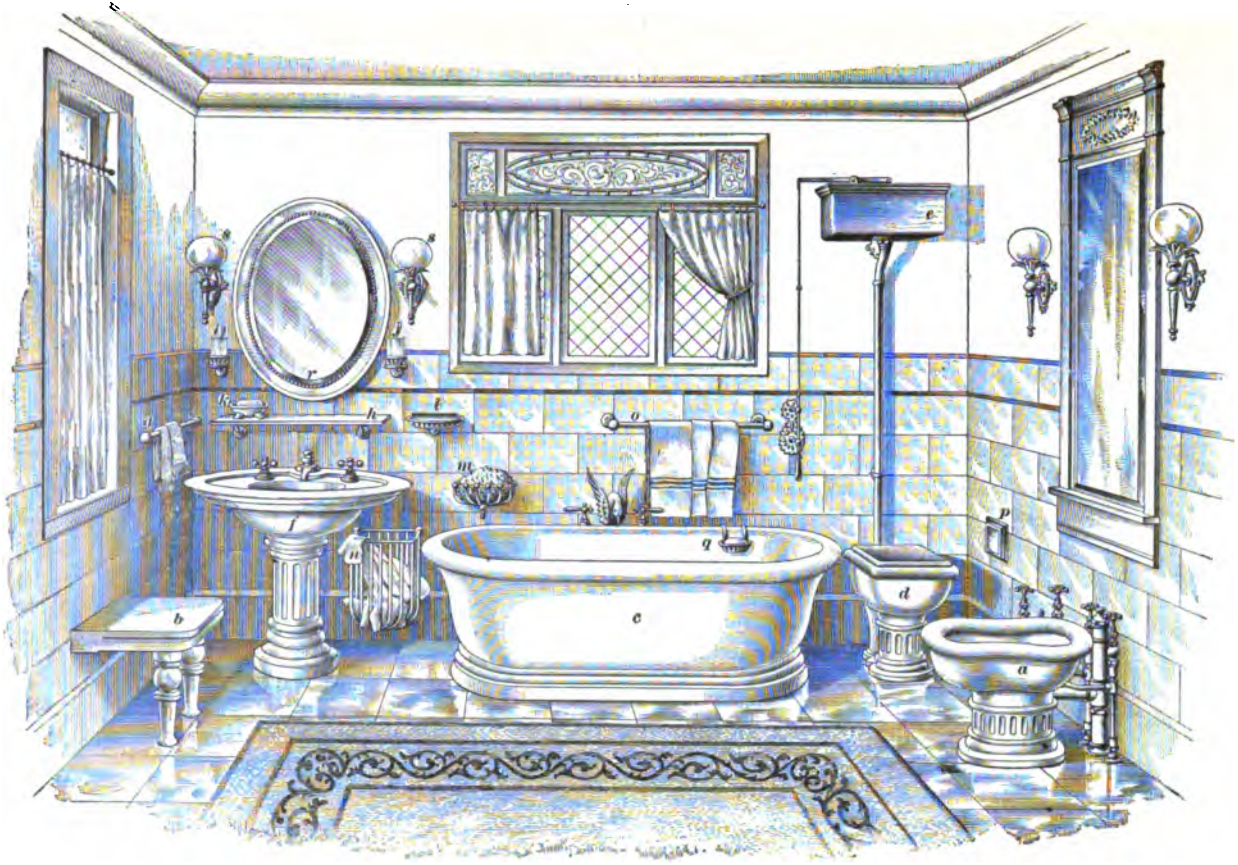

FIG. 26

HIGH-GRADE BATHROOM EQUIPMENT

37. A high-class bathroom fully equipped and having the fixtures excellently arranged is shown in Fig. 26. An all-porcelain bidet *a* with flushing rim and nickel-plated supply and waste fittings is shown at the extreme right of the illustration, and a porcelain bathroom seat *b* is located under the window at the extreme left. The bath *c* is all porcelain and of the Roman type. It is set out from the back wall a few inches to allow space for the supply valves and standing waste and also for cleaning purposes. The water closet *d* at the right of the bath is ornamental and of the siphon-jet type. The flushing tank *e* is enameled white to match the closet seat, or it may be of porcelain to match the closet and other fixtures. The basin *f* located at the left of the bath is of the latest pattern; it is in the form of a pedestal, being independent of the wall. The lavatory fittings shown are composed of a glass towel rack *g* 24 inches long, a porcelain shelf *h* with brackets, a china vase *i* serving as a tooth-brush holder, a cut-glass tumbler and holder *j*; a china soap dish and holder *k*, a comb-and-brush rack *l*, a sponge rack *m*, a rack *n* for soiled towels, etc., a glass towel rack *o* 30 inches long at the back of the bath, a recess paper holder *p*, the body of which is let into the wall, and a soap dish *q* for the bath. The floor is tiled and should be water-tight. The walls also are tiled to a height of about 5 feet. The bevel-edged mirror *r* with white enameled frame and the two gas or electric lights *s*, *s* over the basin are conveniences that should not be omitted.

In bathrooms of this class all the porcelain goods should be of the finest grade, known to the trade as A, particular care being taken to purchase from a reliable supply house in America. There is no need of sending to Great Britain, Germany, France, or any other foreign country for fine plumbing fixtures, because the American goods are the finest. They are even shipped to, and installed in, the homes of foreign nobility.

URINALS

URINAL STALLS

CONSTRUCTION

38. Purpose. — Urinals form a class of plumbing fixtures that is used extensively at places where men congregate, such as hotels, office buildings, railroad stations, etc. They are seldom used in private residences, for the modern closet with a hinged seat is a substitute for a urinal.

39. In public places, where urinals are liable to receive improper usage, it is customary to construct simple *urinal stalls* of slate, porcelain, or marble, providing each stall with means for being flushed down from the top, and with a drain at the bottom to remove the flushing water and urine.

40. Flat-Slab Urinal Stalls.—Fig. 27 shows a common cheap set of **flat-slab urinal stalls.** The floor slab, or safe, *a* is one piece from end to end. It should be thick enough (3 or 4 inches, according to its length) to allow a gutter *b* to be cut the full length. At the lowest point of this gutter, a brass strainer connection allows the waste water to flow through a 4-inch trap and waste pipe to the sewer, a screw-cap being placed at *c* for access to the waste pipe, should it become choked. A ¾-inch brass perforated pipe *d* is used to flush the backs of the stalls. A stop-cock or valve is placed at *e* to control the supply of water to the stalls. The janitor in charge should have a key in his possession for operating this valve.

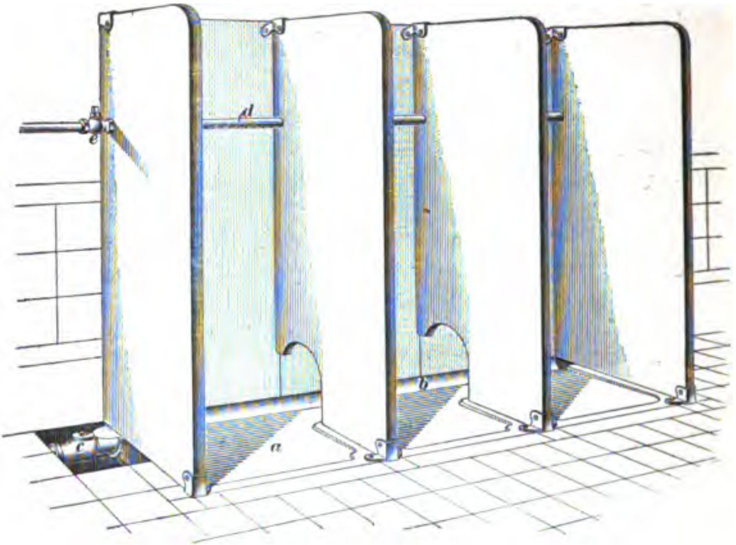

FIG. 27

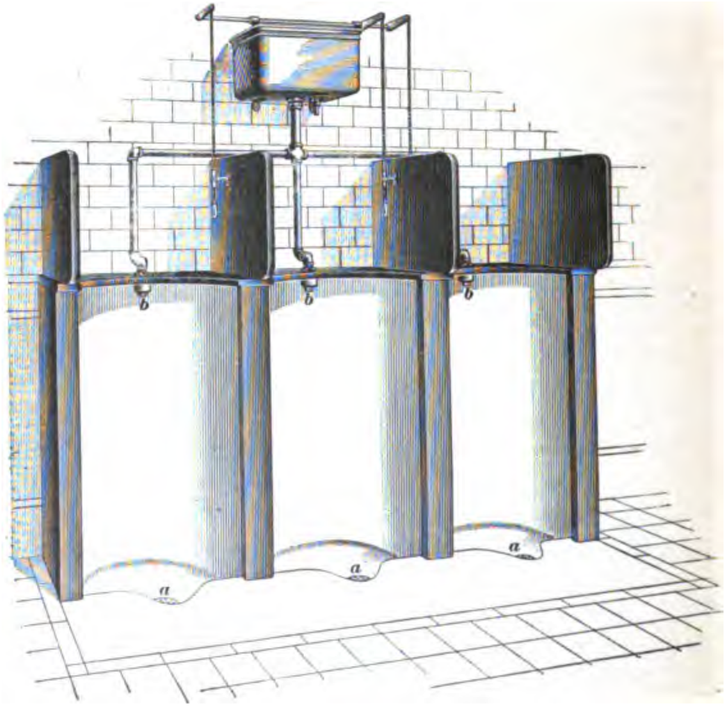

FIG. 28

This arrangement not only wastes too much water, but also is not a sanitary fixture, because the corners become foul and the joints are liable to leak and saturate the building with a weak solution of urine. The slab *a* also becomes foul and is not cleansed by the flushing.

41. D-Shaped Porcelain Urinal Stalls.—Fig. 28 shows in perspective, and Fig. 29 in section, a **D**-shaped porcelain urinal stall. The sides, back, and bottom, or sill, of each stall are molded in one piece. The sill is dished out, and forms an excellent receptor, permitting thorough flushing. Each stall has a separate waste connection *a* and a separate flushing inlet *b*. Each stall may also be trapped separately, the trap being located directly under the floor strainers. If it is convenient to local vent the stalls, one trap may be used for all the stalls, and the local-vent pipe may connect to the highest end of the untrapped waste-pipe line under the stalls. This ventilates each stall from the floor. The flushing inlet shown at *b* is of the fan type. It spreads the water over the urinal surface, and is superior to the perforated pipe attachment shown in Fig. 27, because the perforations in the latter frequently become choked, which spoils the distribution of the water. The fans are made adjustable, so that they can be regulated to suit the pressure and volume of water required. This style of urinal stall is to be recommended for public use where a constant flush of water can be obtained.

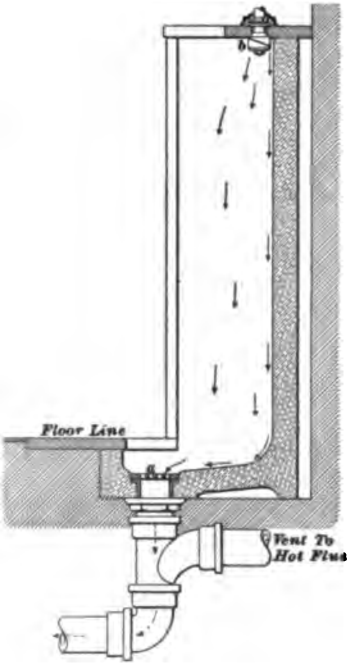

FIG. 29

INDIVIDUAL URINALS

URINALS WITH SEPARATE TRAPS

42. Construction.—**Individual urinals** are made of porcelain and are provided with at least two openings, one being the flushing inlet and the other the discharge. The best class have perforated flushing rims and overflow openings inside. Urinals that are fastened against the side of the room are known as **flat urinals,** while those placed in a corner are spoken of as **corner urinals.**

43. Fig. 30 shows a **plain flat urinal,** with a flush supply horn *a*, a waste horn *b*, a flushing rim *c*, an overflow *d*, and lugs *e*, *e*, by which the urinal is secured to the wall with screws or expansion bolts.

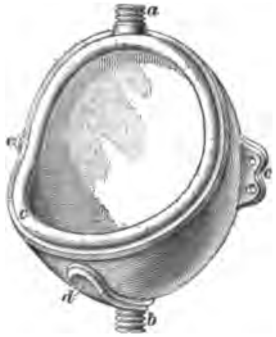

FIG. 30

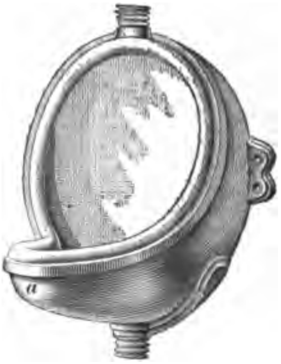

FIG. 31

44. A **flat lipped urinal** is shown in Fig. 31. It is substantially the same as the plain urinal, excepting that a lip *a* is provided. This is the best form of urinal, because the lip protects the floor.

45. Urinal Connections.—Fig. 32 shows a compression urinal valve that may be attached at *a* in Fig. 30 to give the urinal a continuous flushing from the cold-water supply pipe in the building. A locknut *a* on being screwed up tight makes a rigid connection to the marble slab *b*.

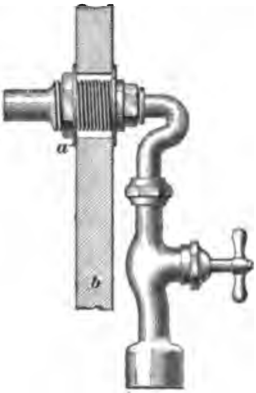

FIG. 32

46. Where urinals are flushed from an overhead flushing tank, a much simpler form of urinal inlet connection than that shown in Fig. 32 can be employed. Such a connection is shown in Fig. 33, and is seen to be similar to the one shown in Fig. 32, except that the valve is omitted.

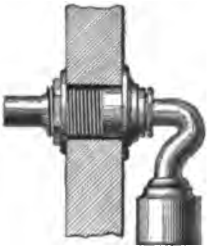

FIG. 33

47. A urinal trap connection is shown in Fig. 34. The horn *a* of a cast-brass trap *b* is slipped over the outlet horn of the urinal, and is made water-tight with a red-lead joint. A brass **T** piece *c*, the lower opening of which joins the waste pipe, and the upper opening joins the vent pipe, is secured by locknuts to the marble slab *d*. A slip joint with a rubber gasket is made at *e*, which allows the trap to be adjusted to suit the urinal. A better connection, however, is that in which the trap is secured to the **T** piece and a metal-to-metal joint obtained.

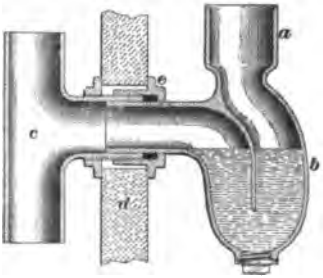

FIG. 34

48. If the trap can be set behind the wall or slab against which the urinal is set, the waste connections may be made as shown in Fig. 35. This shows a bend *a* under the urinal, a clean-out screw-cap being located at *b* for cleaning out purposes. A lead trap *c* is shown wiped to the bottom of the **T** piece; a local-vent pipe is wiped to the upper opening. This makes a good connection if the draft of the local vent can be relied on.

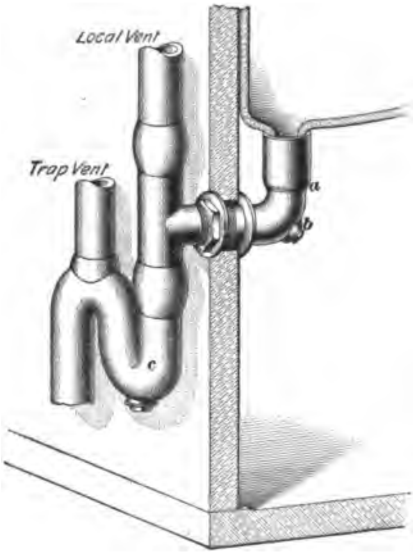

Fig. 35

URINALS WITH COMBINED TRAP

49. Advantages.—It has been found by practical experience that no brass work of any description should be exposed near a urinal, because it soon becomes coated with verdigris and cannot be kept clean and bright. The nickel-plated brass waste connections so often used in connection with common urinals soon become corroded, green, and unsightly. To avoid .this trouble, a special urinal with porcelain trap may be used.

50. Porcelain Trap Urinal.—An objection to common urinals that are provided with a trap under them, and which are dry between flushings, is that the interior surface of the urinal and the space between the urinal and the trap seal becomes foul and emits disagreeable odors. In the best urinals this fouling surface is reduced to a minimum. Fig. 36 shows such a urinal. It has a porcelain trap *a* combined in one piece with the bowl, and is arranged to be connected without any metal parts being exposed. The section *b* of the trap on the sewer side of the waste seal is made of brass; it is encased by the earthenware and screwed into a special brass waste-pipe **T** fitting *c*. This section forms the inlet to the waste pipe and is provided with a flange and bolts for making a perfect junction with the porcelain. The joint between the brass connection and the earthenware being submerged, or below the water-line, is gas-tight. This is equivalent in security to an all-metal trap, and has the additional cleanliness of a porcelain one. A neat little drip is attached under the lip of this urinal at *d*, which prevents drops of urine from trickling along the under side of the urinal and fouling that surface.

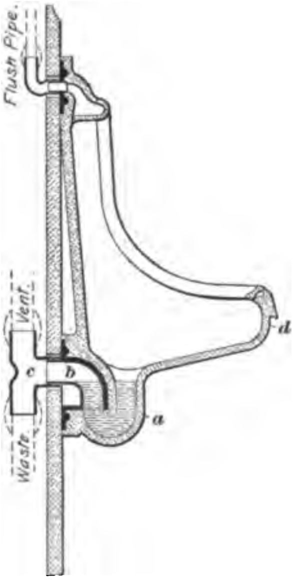

FIG. 36

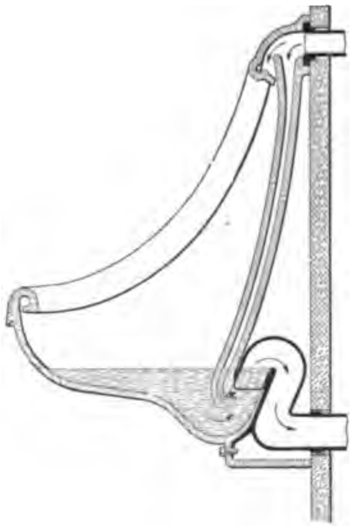

FIG. 37

51. Siphon-Jet Urinals.—To reduce the urinal fouling surface to a minimum, and to insure the urinal being partly filled with water at all times, a **siphon-jet urinal** shown in Fig. 37 may be used. It is constructed on the siphon-jet principle, and porcelain only is exposed to view. The urinal proper contains a body of water about 9 inches long by 8 inches wide.

This urinal is furnished with a flushing tank and operates in a manner similar to that of an ordinary siphon-jet water closet. When the tank is discharged, part of the water cleanses the interior of the urinal, the other part being diverted to the jet that starts the siphon and ejects the contents of the urinal. The joint between the brass and porcelain is under water and, of course, is quite safe.

VENTILATED URINALS

52. A **ventilated urinal** that is especially valuable in places where it is necessary to positively ventilate the urinal and the floor under the urinal, which incidentally means the ventilation of the entire toilet room, is shown in Fig. 38. A large vent pipe *a* is continued to, and above, the roof. If it cannot be run in a hot place, to insure a strong draft, it is necessary to place a fan in the vent pipe to constantly draw in air through the openings *b* and *c*. The inside of the pipe *a* is likely to become coated with a foul-smelling slime, and if the ventilation is not perfect, the odor will escape into the toilet room through *b* and *c*. The lower opening *b* is especially valuable for removing wash water while the floor is being washed.

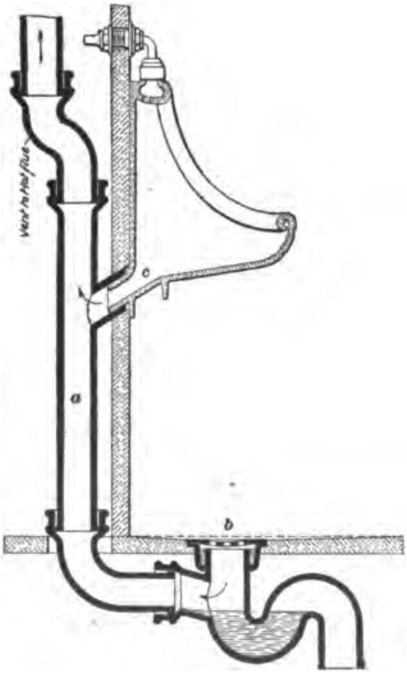

Fig. 38

Sometimes men throw cigar stumps into urinals, which choke the ordinary forms. The urinal shown in Fig. 38 cannot be choked very easily, because the outlet *c* is straight and the drainage pipe large.

TILTING-TANK URINALS

53. A low-down **tilting-tank urinal** is shown in Fig. 39. A porcelain extension box *a* is molded on top of the urinal. In this box is located a tilting tank *b* that is supplied by a small stream of water from a stop-cock *c*, serving to check the stream down to the desired size. The tilting tank automatically flushes the urinal through a flushing rim and perforations in the bottom of the extension box. A loose cover *d* can be removed for access to the tank. This form of urinal is adapted for locations under windows, etc., where it is impossible to place an overhead flushing tank. They are seldom used.

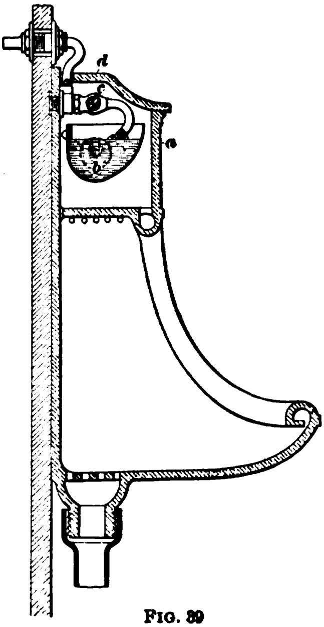

FIG. 39

TREADLE URINALS

54. If water is so scarce that a continuous flush cannot be permitted, a **treadle urinal** having an automatic arrangement similar to that shown in Fig. 40 may be used. The supply valve *a* is of the self-closing type, and the valve stem projects upwards against a hinged platform or treadle *b*.

To use the urinal, a person must stand on the treadle, which yields sufficiently under his weight to open the valve. The water flows as long as the treadle is depressed, and ceases as soon as the weight is removed from it. A small part of the water is used to flush the treadle box and remove the drippings that may fall into it. The waste pipes *c* and *d* and the trap *e* should be not less than 1½ inches in diameter.

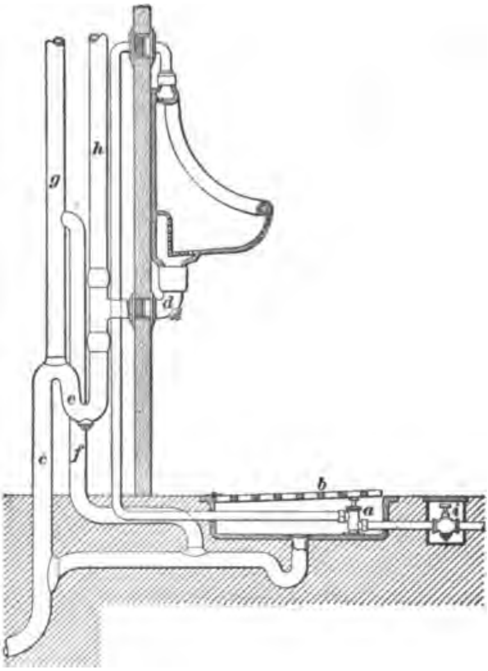

FIG. 40

The waste and trap from the treadle box should be at least 1¼ inches in diameter. The waste pipe from the treadle box should be vented by a 1¼-inch or 1½-inch pipe *f*, which should join the principal vent pipe *g*. The diameter of *g* should be not less than 1½ inches. The local vent or ventilating pipe *h* should be 2 inches in diameter, and care must be taken to get a good draft of air through it. The stop-cock *i* is used to shut off the water supply.

55. Attachments that open the supply valve and allow the water to run are sometimes fastened to the door of the stall in which the urinal is enclosed, so that a given quantity of water will be discharged into the urinal every time the door is opened. Consequently, the urinal will be flushed before and after use. The door is closed by a spring or weight.

FOLDING URINALS

56. Folding urinals made of iron or porcelain, operating in a manner similar to a folding wash basin, are sometimes used. They are flushed by a cock being opened with the cover of the urinal. The cock is shut when the cover is raised and closed. This apparatus is usually set in a recess of the wall, and is provided with a local-vent pipe, as it is often fitted up in rooms where the least smell would be disagreeable, such as doctors' offices.

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